MUTABLE MEMORIES: THE MISINFORMATION EFFECT AND BLENDED MEMORY RESPONSES

A Thesis
submitted in partial fulfilment of the requirement
for the degree of

Master of Arts
in
Psychology

at the
University of Canterbury

by
Russil Durrant

It is not logically necessary to the existence of a memory-belief that the event remembered should have occurred.

Bertrand Russell, The analysis of mind. MacMillan, 1921.

Table of Contents

Acknowledgements

Many thanks to my supervisor, Gill Rhodes, for her knowledge, help and patience with a capricious student. Special thanks to Frances for the word processing and help with the running of the second experiment. To Mark, Tony and Chris for providing much needed technical help and finally to David Murray for keeping everything in perspective.

Abstract

The finding that misleading post-event information can impair subjects' reporting of originally presented items has led to numerous theoretical explanations: It is alternatively being suggested that the effect is due to demand characteristics, response bias (McCloskey & Zaragoza, 1985a), overwriting of information (Loftus, 1975), retrieval impairment (Christiaansen & Ochalek, 1983), trace integration (Loftus, 1977), or source misattribution (Lindsay & Johnson, 1988). Two experiments were conducted which demonstrated that when a misleading, interpolated face was presented after an original event face subjects most frequently selected a blend face option on the recognition test, representing aspects of both faces shown. It is argued that demand characteristics, response bias, source misattribution or overwriting cannot account for the results found. Instead, a summed similarity exemplar model or a prototype model are suggested as the most cogent theoretical frameworks for explaining the misinformation effects found.

Introduction

The efficacy of eyewitness testimony has been under question for some time (e.g. Buckhout, 1974). It has been suggested that the most likely cause of the wrong conviction, assuming the integrity of the legal system, is mistaken identity (Cole & Pringle, 1974). The ease with which witnesses make mistakes in personal identification also has interesting implications for the way memory works and how information is represented in the brain. Experimental studies assessing the accuracy of memory in simulated eyewitness testimony situations concur with the real life accounts in concluding that memory is imperfect and easily influenced by factors such as misleading information (Loftus, 1975). The basic design of these eyewitness memory experiments is as follows: Subjects are visually presented with an event, such as an auto-pedestrian accident or simulated robbery; half of the subjects are then exposed to misleading information, that is, it is suggested that subjects saw certain items which weren't in fact present in the original event. Subjects who received misleading information are subsequently impaired in their recognition or recall memory response for the original event item or items. This influence of post-event misleading information on memory response for an original event is termed the misinformation effect.

The aims and general outline of this thesis are as follows: First I will review the experimental findings relating to the misinformation effect, focussing on when the effect occurs and what variables can influence its magnitude. Then I will examine the various theoretical approaches proposed to account for these findings. These explanations will be related to some wider theoretical issues concerning memory and memory representation. Two experiments will be presented which were designed to assess the validity of the various theoretical approaches proposed to account for misinformation effects. The results of these experiments will be discussed in terms of some of the ideas and theories elucidated in the first three sections.

Experimental findings

In a series of experiments designed to test the effects of post-event misleading information Loftus and her colleagues (Loftus, 1975; Loftus, Miller & Burns, 1978) got subjects to view a slide sequence depicting an auto-pedestrian accident. In this sequence a red Datsun was seen traveling along a street towards an intersection having either a stop sign or a yield sign. The car then turns right and knocks down a pedestrian who is crossing the road. After viewing the slide sequence subjects were given a questionnaire containing items pertaining to the event. The critical question was as follows: "Did another car pass the red Datsun while it was stopped at the (yield) stop sign?" Half of the subjects received consistent information; that is, if they viewed a yield sign in the slide sequence then they received a question mentioning *that* yield sign whereas the other half received inconsistent information: The questionnaire presupposed that a stop and not a yield sign was present. After a 20 minute filler activity a forced choice recognition test was administered. Subjects were presented with 15 pairs of slides; for each pair, one item had been seen previously in the event, whereas the other slide was a novel non-viewed item. Subjects had to select which slide they had previously seen in the original event sequence. The critical slide pair was one of the red Datsun either at the yield sign or at the stop sign. The results demonstrate that those subjects who received misleading or inconsistent information were less likely (41% of subjects) to select the correct (original) slide than subjects who had received consistent information (75% correct).

The misinformation effect has been replicated in numerous experiments, with different stimuli and under different conditions of encoding and retrieval. Whether the original event is an auto-pedestrian accident (e.g. Loftus et. al, 1978; Bekerian & Bowers, 1983; Bowers & Bekerian, 1984), a simulated robbery (e.g. McCloskey & Zaragoza, 1985), a single slide of a cluttered room (Lindsay & Johnson, 1989), a class uprising (Loftus, 1975), detailed pictorial nature scenes (Chandler, 1989), or faces (Jenkins & Davies, 1985; Gibling & Davies, 1988): All other things remaining equivalent, misleading information decreases reporting of the original event.

The misinformation effect has also been reported under different modes of post-event information presentation, whether it be in the form of verbal presuppositions (Loftus et. al, 1978; Bekerian & Bowers, 1983), a detailed narrative of the event with embedded misinformation (McCloskey & Zaragoza, 1985) or visually presented misleading information (Jenkins & Davies, 1985; Chandler, 1989).

Variations at test, such as giving subjects a yes/no recall questionnaire (Loftus, 1975; Tversky & Tuchin, 1989; Belli, 1989) or a range of choices on a continuum, where this is psychologically plausible (Loftus, 1977; Belli, 1988), both reveal effects of misleading post-event information on memory reporting for an original event.

However, certain other manipulations of variables at encoding and retrieval, such as the type of test used, have been shown to attenuate or eliminate completely the effect of misleading information. In a series of experiments, McCloskey and Zaragoza (1985a) used a modified forced-choice recognition test in which subjects, instead of choosing between the original item (a hammer in this case) and the misleading item (a screwdriver), as in the Loftus et. al (1978) design, had a choice between the original item and a completely novel, but similar item (a wrench). Under these test conditions misled subjects were no more likely to report the misleading information than were controls. The same results were found when a modified *recall*, instead of recognition, procedure was used (Zaragoza, McCloskey & Jamis, 1987). In the Zaragoza et. al (1987) experiment subjects were asked questions about their memory for the slides that constrained the type of responses they could make. For example, one critical question was: "The keys to the desk drawer were next to a soft drink can. What BRAND of SOFT DRINK was it?" (the misleading item was a can of Planters peanuts). The results demonstrated that recall performance for control items (33%) was identical to that on misled items. As can be seen, the type of test used in terms of response options can affect the degree of misinformation reporting found.

Another variable that affects the misinformation effect is discriminability between the two sources of information. When subjects are made aware of the difference between the two sources of information (event and post-event), the effect of the misleading information appears to be diminished. This general finding has been revealed in a number of different studies using slightly different experimental procedures. If subjects are given a warning that some or all of the post-event information might be incorrect then their subsequent reporting of this information is considerably reduced. Green, Flynn and Loftus (1982) found that warnings were only effective when they were given *prior* to the introduction of misleading information, while Christiaansen and Ochalek (1983) found that subjects were no more likely than control subjects to report misleading information even when warnings were administered *after* the presentation of post-event information. The nature of the warning in their study, however, was more explicit than in the Green et. al (1982) experiment; also the interval between the event and post-event information was considerably longer than that used by Green et. al (1982), which may have facilitated discrimination between the two sources.

In studies directly assessing the effects of source monitoring (Lindsay, 1990; Lindsay & Johnson, 1989; Zaragoza & Koshmider III, 1989), the consistent result is that when subjects are explicitly asked to discriminate between items they have previously *seen* and items *read* in the post-event narrative, the effect of the misinformation on subsequent reporting of the event items is negligible, although Lindsay (1990) only found this result in the "high discriminability" condition of his experimental design when the post-event narrative was presented two days, as opposed to immediately after, the initial event sequence. It would seem that when the event and post-event items are sufficiently discriminable, reporting of the misinformation is considerably diminished.

Scrutiny of the post-event information and the plausibility of the misleading item(s) also influence the degree of misinformation reporting. Tousignant, Hall and Loftus (1986) found that when subjects were instructed to read the post-event information more slowly and carefully there was greater detection of the discrepant information and a subsequent increase in the accuracy of the misinformed subjects on the final test. If the misleading information is implausible or blatantly contradictory in relation to event information the misinformation effect is also diminished (Loftus, 1979). Furthermore, the implausibility of one item seems to lead to resistance to suggestions about other (more subtly misleading) items (Loftus, 1979).

Another variable which modifies the effect of misleading information is the contextual environment of the testing phase. The usual recognition (or recall) test presents questions about items seen in random order; that is, the test sequence of slides or questions is not in the same order as the originally presented information. However, when a sequential test order is imposed the effect of post-event information on reporting of original events is diminished (Gibling & Davies, 1988) or completely eliminated (Bekerian & Bowers, 1983; Bowers & Bekerian, 1984).

In contrast to the studies cited above, various other, different, manipulations can *increase* the likelihood that subjects' final reporting will reflect the suggested items rather than the real ones. For example, peripheral or more plausible misleading items are more likely to contribute to the reporting of misinformation than more focal or obviously different ones (Loftus, 1979).

All other things remaining constant, the longer the retention interval between the event and the post-event information the greater the impact of the misleading information. In experiment three by Loftus et. al (1978) the proportion of correct responses by misled subjects dropped from 40% at a 20 minute retention interval to 20% after an interval of one week. The impact of the suggested information, it would seem, is greater if the original information was viewed at longer intervals from the suggested information and subsequent questionnaire.

Describing misinformation within a parenthetical clause also leads to a higher degree of reporting of the misinformation by misled subjects (Loftus, 1981). For example, a luggage rack was more likely to have been reported to have been seen when suggested in a complex presupposition: "Was the station wagon, which was equipped with luggage racks, carrying a large carton?" than in a simple one: "Were the luggage racks on the getaway car holding a large carton?"

Loftus (1981) has proposed a simple probabilistic model which predicts the likelihood of reporting misinformation in a given situation. According to the model:

$$Ps = Pc\ Pa$$

Where Ps is the probability of reporting the suggested or misleading information; Pc is the probability of comprehending the post-event information; and Pa is the probability that the post-event information is accepted as valid. Other factors which influence the reporting of misinformation are the discriminability between the two sources of information and the type of testing procedure employed. In summary, the misinformation effect will be reduced or eliminated when the two sources of information are highly discriminable or when the test conditions either preclude the possibility of responding with the suggested item or provide contextual cues that reinstate the originally viewed learning conditions. The effect will be larger when the event and post-event items are not particularly discriminable and when the subjects are given an opportunity of responding with the misleading item at the time of the test.

What is the fate of memory? - theoretical accounts of the data

Various different theoretical models have been proposed to account for the effects of misinformation on subsequent reporting of original event items. It has been alternatively suggested that the misinformation effect is due to (i) trace alteration, (ii) retrieval impairment, (iii) response bias and demand characteristics, (iv) source misattribution, and (v) memory blending. An understanding of exactly why subjects so readily report seeing misleading items can lead to insights into the nature of memorial processing and the relative permanence of stored information in the brain.

(i) Trace alteration

The initial finding that misleading information could impair subjects' reporting of original event items led Loftus and her colleagues (Loftus et. al, 1978; Loftus, 1979) to postulate that the new information 'replaces', 'overwrites' or 'updates' the existing information so that the original information is irrecoverably lost. After experiencing an event an individual forms a representation of that event in memory. If new, potentially relevant, information is subsequently introduced, the original representation is updated or overwritten to accommodate the new information (Loftus, 1979).

Tulving (1983) suggests that mutability of memory traces or 'engrams' is one of the fundamental characteristics of memory and learning. A recoding paradigm states that when interpolated events are introduced to subjects with existing representations for original events, all other variables being constant, impaired recollection of those original items will reflect a recoding or change in the memory engram (this approach is summarised in Table 1).

Rememberer	Original event	Interpolated event	Recollection of the original event
A	Yes	Yes	No
B	Yes	No	Yes

Table 1: Recoding Paradigm (modified from Tulving, 1983, p. 165)

Exactly how the traces may be altered is an as yet unresolved issue. Loftus and Hoffman (1989) speculate that trace alteration could be due to a weakening of memory traces, a clouding of memory, unlearning, or a disintegration of features. However, all these terms are somewhat vague and there seems to be little empirical evidence to support one mechanism over the other.

It is also possible, speculates Loftus (Loftus et. al, 1978), that the two sources of information may *both* reside in memory and that they interfere with each other at the time of retrieval so that there is differential access to the misleading item. To test this hypothesis, and to see whether the original memory *could* be retrieved under different experimental conditions, Loftus (Loftus et. al, 1978) told subjects, after making their original selection, that there might have been some misleading information in the questionnaire. Subjects were asked to indicate 1) what they *saw* (yield or stop sign) and 2) what their questionnaire mentioned. Few subjects who were misled changed their mind or indicated that there was a discrepancy between the two sources of information. Naturally there is a problem in this study, in that admitting to a difference or changing choice selection is tantamount to admitting to dishonesty in the original recognition test.

As already mentioned, Greene et. al (1982) also used a warning in their experiment, and found that it was only effective when presented *prior* to the misinformation, not when it was given before the final recognition test and *after* the misleading information. They concluded that while subjects could pick up the discrepancy in the misinformation when warned, they could not edit out misleading suggestions once encoded in memory.

(ii) Retrieval impairment: the coexistence hypothesis

A problem with the overwriting or permanent alteration hypothesis, as Loftus acknowledges (Loftus & Loftus, 1980), is that results from the misinformation paradigm can only be *suggestive* of such a permanent change in memory traces. As Christiaansen and Ochalek (1983) state: "One can always argue that the original memory still exists but the appropriate retrieval method was not used." (p. 468). This type of argument, of course, has been used, perhaps erroneously, to support the claim that all information 'cognitively registered' is retained in memory in the form of veridical and unalterable memory traces (see Loftus & Loftus ,1980, for a critique of this view). However, in terms of the misinformation effect, if original event information can be retrieved after misleading information is presented, then this would argue against a permanent overwriting and support a coexistence hypothesis.

Christiaansen and Ochalek (1983) suggest that the warnings used in the Green et. al (1982) and Loftus et. al (1978) studies were insufficiently explicit. Subsequently a clearer warning was given to subjects in the experiments conducted by Christiaansen and Ochalek (1983). After reading the post-event narrative the subjects were told: "A *few* of the details in the description are *inaccurate* - some of the details are correct and a few are incorrect. Take a minute to think about the description..." It was found that misled subjects *could* edit out the misleading information and their recognition of event items was equal to that of control subjects. It must be noted however that the analyses was restricted to items that had been previously shown to be remembered. Warnings may only be effective when the original information is well remembered. Subjects were also given a test after the initial event (and before the narrative). This additional test may well have strengthened the subjects' memories for the original items and made them more resistant to the effects of misinformation.

Other studies which support a coexistance as opposed to overwriting hypothesis have manipulated variables at retrieval to demonstrate that under certain conditions the original information is recognized equally well by both control and misled subjects (Bekerian & Bowers, 1983; Bowers & Bekerian, 1984; Gibling & Davies, 1988). By imposing a sequential test order (one that mimics the sequence of the original event) as opposed to a random test order, Bekerian and Bowers (1983) found that recognition of an originally viewed item was the same for the control group (85%) as it was for misled subjects (87%). These results have been replicated using the same stimuli by Bowers and Bekerian (1984) as well as by Gibling and Davies (1988) using schematic faces.

Proponents of the coexistance hypothesis have argued that forgetting is a result of problems in *retrieving* old memories that are otherwise (individually) present in the system. Access to original information is dependent on the contextual environment at retrieval and the types of retrieval cues used. However, although the warning and context reinstatement studies seem to suggest that the old information is still *accessible* in some form, they don't conclusively prove that the two pieces of information 'co-exist' as separate memory traces. Perhaps the event and post-event items are integrated or preserved in some kind of unitary memory trace: this possibility is examined in more depth later in the thesis.

Loftus and colleagues have argued (Cole & Loftus, 1979; Tousignant et. al, 1986; Loftus et. al, 1989) that if a person resolves the (potential) conflict between two discrepant sources of information at the time of retrieval, then this should be reflected in longer response times (RT) for misinformed than for control subjects. In several experiments it was found that RTs *did not* differ for control and misled subjects. Confidence ratings were also equivalent so that misinformed subjects were as confident in reporting their errors as non-misinformed subjects were in reporting the original information. Cole and Loftus argued that if there is any conflict between the two sources of information it must be resolved at the time the misinformation is presented.

The problem with these types of studies is that they hinge on the idea that the misinformation effect may be the result of some kind of conscious deliberation process; it is not necessary to assume, taking into account the parallel nature of neural processing, that RTs will be slower if the items are represented independently than if they are somehow integrated together. Although the reaction time data is perhaps uninformative with regards to coexistance or integration at either the time of the initial presentation of the misinformation or during the recognition test, it does seem to argue against any kind of conscious deliberation process of comparing discrepant items at the time of retrieval. Therefore the assimilation of misinformation into memory may be at a relatively unconscious level.

(iii) Non-memory effects

Although, as it has been seen, the different memory impairment hypotheses are difficult to tease apart, McCloskey and Zaragoza (1985a) have suggested that the introduction of misleading information has *no* effect on memory for an original event; or more precisely, the methodological designs used have been inappropriate for assessing a memory impairment hypothesis. They argue that demand characteristics, response bias, and misinformation acceptance can account for all of the discrepancy in responding between control and misled subjects in misinformation experiments.

Their argument runs as follows: Because success rate isn't 100% in the control group, presumably not everyone can remember the original slide. These subjects will then be merely guessing in the recognition test and have a 50% chance of choosing the correct item. However, subjects who have forgotten the original slide but received the misleading information will be biased in selecting the new information, for reasons other than 'overwriting' or 'updating'. Moreover, subjects could remember both the original *and* misleading information and select the misleading information because they trust the experimenters' memory better than their own. The results, then, could be due in part to demand characteristics.

To counter these problems McCloskey and Zaragoza (1985a) used a similar experimental procedure (substituting a theft for the auto-pedestrian accident in the slide sequence) except that in the recognition phase subjects were given a choice between the original item (a hammer) and a novel item not previously encountered (a wrench). The misleading item was a screwdriver. This design is referred to as the <u>modified recognition test</u>. If misleading information really does impair memory for the original event, then the misled group should choose "hammer" less often than the control group. In fact there was no difference between the two groups. The basic results of this experiment have also been replicated using a recall rather than a recognition test (Zaragoza et. al, 1987). In summary, McCloskey and Zaragoza conclude that misleading information has no effect on subjects' ability to either recall or recognize suggested information. The misinformation effect, they argue, can be equally well accounted for by response biases and/or demand characteristics inherent in the standard experimental design.

However, Loftus, Schooler and Wagenaar (1985) argue that the testing procedure employed by McCloskey and Zaragoza was simply not sensitive enough to reveal the impact of post-event information. Studies by Benzing (1985, cited in Loftus et. al, 1985) and Chandler (1989) also using the modified recognition test, were able to detect differences, with misled subjects performing more poorly than controls on recognition of the original item. However, the effect is somewhat smaller than usually obtained and different stimuli (Chandler, 1989) or a slightly different testing procedure (Benzing, 1985, cited in Loftus et. al, 1985) were used. When the additional measure of RT is used on the modified recognition test it is found that while accuracy is equivalent for both misled and control subjects, RTs are significantly slower for those subjects that had been exposed to suggested information (Loftus, Donders, Hoffman & Schooler, 1989). Loftus et. al (1989) argue that misinformation *does* have an influence on subjects' memory and that the increased RTs on the modified test are an indication of that influence.

As Belli (1989) suggests, another problem with the modified test paradigm is that it fails to allow for the possibility of preferential accessibility of the post-event information (by not including it in the recognition test); that is, it *may* be in memory and given an opportunity, obfuscate access to the event item. Furthermore, subjects could succeed in the McCloskey and Zaragoza experiment in two ways: (1) by correctly accepting the original information, or by (2) correctly rejecting the novel information. Even if subjects are not exactly sure what they did see, they may succeed if they know what they didn't see. For example, although a misled subject may not be sure whether they saw a screwdriver or a hammer they probably know that they did not see a wrench. Consequently their response choice is for the original event item.

To counter this problem both Belli (1989) and Tversky and Tuchin (1989) employed yes/no recognition tests whereby misled and control subjects were asked whether they had seen each item in turn (see Table 2 for a summary of the different designs).

Condition	Slides	Narrative	Loftus	McCloskey & Zaragoza	Tversky & Tuchin
Control	Coke	-	Coke vs. 7-up	Coke vs. Sunkist	Coke? 7-up? Sunkist?
Misled	Coke	7-up	Coke vs. 7-up	Coke vs. Sunkist	Coke? 7-up? Sunkist?

Table 2: Summary of Experimental Designs

In the misled condition of Tversky and Tuchin's (1989) procedure subjects recognized (or said "yes" to) fewer event items than the control group, while responding affirmatively to more misleading items. Both control and misled groups were equally good at rejecting the novel foils (i.e. they knew what they *didn't* see). Tversky and Tuchin concluded that while it is impossible to know exactly what is happening in memory, their results make it unlikely that response bias or demand characteristics can account for all of the differences in responding between control and misled subjects.

(iv) Source misattribution

A different approach to the misinformation effect is to view it as the result of a source misattribution (e.g. Lindsay & Johnson, 1989; Lindsay, 1990). According to this hypothesis, subjects may be able to remember one, or both, of the items of information but they are unsure of the *source* of their memory. That is, they are not sure if their memory is for what they *saw* in the original event, or whether it is for suggested items in the intervening narrative/questionnaire. If the post-event information is easier to gain 'access' to for some reason (e.g. it is more recent) then there may be a bias to infer that its source lies in the original event.

Experiments that have explicitly asked subjects to indicate the source of their memories, i.e. to indicate whether the items were 1) seen, 2) read, 3) both, or 4) neither (Lindsay & Johnson, 1989) have demonstrated that when attention is directed to the source of the items, the misinformation effect is eliminated. Misled subjects were no more likely to claim they had *seen* the misleading items than were control subjects. Zaragoza and Koshmider III (1989), using a similar design to Lindsay and Johnson (1989), also found that misled subjects didn't believe that they *saw* the misleading items. Nor did the misinformation make subjects less able to remember the source of the original items.

Lindsay (1990) manipulated discriminability between the two sources of information so that in the low discriminability condition the post-event narrative was presented immediately after the slide sequence and was read out, in the same (female) voice that accompanies a description of the slides. In contrast, subjects in the high discriminability condition heard the post-event narrative 48 hours after viewing the slides, and the narrative was read out in a different (male) voice than that which accompanied the original event. Both groups of subjects took part in the memory test 48 hours after the slide presentation. All subjects were told just prior to taking the memory test that any relevant information presented in the narrative was wrong and should not be reported. By telling subjects that information in the narrative was incorrect, demand characteristics and response bias should play no part in any results found. If source monitoring problems really do occur, subjects in the low, but not the high, discriminability condition will sometimes still report the misinformation as a true record of what they originally saw. The results indicated that subjects *did* more frequently report the misled items in the low discriminability condition than when source was easily discriminable. However, for subjects in *both* conditions the misleading suggestions impaired reporting of event details. When discriminability between original and misleading information is low it appears that subjects experience genuine source-monitoring failures which can't be accounted for in terms of demand characteristics or response bias.

The source misattribution hypothesis is given plausibility by studies conducted in the wider area of 'reality monitoring'. Johnson and Raye (1981) have demonstrated that people will quite often mistake memories of imagined events for memories of real ones (and vice versa). While it appears that there are qualitative differences between subjects' memories of real and imagined events, memories for perceived events often having more sensory and contextual details and less 'cognitive' or functional information, these differences are often not fully appreciated by witnesses or subjects asked to report them (Schooler, Gerhard & Loftus, 1986; Johnson, 1988). Indeed, subjects are often as *confident* in reporting their suggested memories as they are their real ones (e.g. Green et. al, 1982).

The likelihood of source monitoring errors appears to be determined by two general factors: "1) the degree of similarity between the target event and other sources of information and 2) the stringency and appropriateness of the decision making criteria employed during memory." (Lindsay & Johnson, 1989, p. 356). The conditions in many experiments designed to examine the effects of misleading information (e.g. Loftus et. al, 1978) are ideal for producing source monitoring errors. Although subjects are generally asked to report the item(s) that they saw, it is assumed (by subjects) that the post-event narrative/questionnaire is a veridical record of the originally presented information. That is, there is no need or motivation to actively discriminate between the two sources. Warning studies, as cited earlier (e.g. Christiaansen & Ochalek, 1983) and context reinstatement experiments (e.g. Bekerian & Bowers, 1983) implicitly help subjects to differentiate the two sources of information and in consequence lead to an attenuation of the misinformation effect.

Although source monitoring difficulties can clearly account for some of the misinformation effect results reported, the finding by Lindsay (1990) that suggested items are still reported even when subjects are explicitly asked not to, suggest some kind of genuine memory impairment problem may be involved as well. A source misattribution hypothesis is also uninformative.with regards to what is present in memory, or the underlying memory representation. It may be that both items somehow 'reside' or are present separately and intact in memory - but are sourceless, or possibly the two pieces of information are combined in some way to form a fused or integrated representation of the two source components.

(v) Memory Blends: The integration hypothesis

The idea of blended or integrated memories has been around for some time. For example, Francis Galton, speculating on the creation of abstract areas, suggested: "Whenever a single cause throws different groups of brain elements simultaneously into excitement the result must be a blended memory" (Galton, 1883, p. 349).

The possibility that information might be blended or integrated in memory has been offered as one explanation for the misinformation effect. According to this viewpoint, information from the two different sources are somehow combined or integrated in memory so that if a real-world blend of the stimuli is possible, and is offered on the recognition test, it will be selected. In the case of the normal forced-choice recognition paradigm, performance is a matter of selecting the alternative *most like* the blend representation in memory. It is possible of course that the two pieces of information are represented separately in memory and that the blend is a result of integration at retrieval. This issue and its theoretical ramifications will be discussed in more depth in the section on 'wider theoretical issues'.

Several experimental studies have been carried out to directly assess the memory blending hypothesis (notably Loftus, 1977; Belli, 1988). In the Loftus study subjects viewed a typical slide sequence in which the critical item was a *green* sports car; misled subjects were subsequently told that the car was *blue*. The results indicate that the misled subjects consistently chose a colour (when presented with a range of choices on a colour wheel) somewhere in between blue and green, while the control subjects selected the original green hue. McCloskey and Zaragoza (1985b) argue that these results reflect not a memory blend but a deliberate compromise between the event and post-event information which both reside, separately but intact, in memory.

Belli (1988) found in his experiments that with increasing retention intervals subjects appeared to use prototypical knowledge about the colour of water pitchers (which are typically yellow, apparently) as a 'default-allowance' to fill in (any) loss of information about the colour of the pitcher shown in the actual slide sequence. Subjects selected a hue which represented a blend between the original information and their prototypical knowledge. A deliberate compromise hypothesis is based on the assumption that both pieces of information exist and reside in memory 'separately'. Belli (1988) argues that if subjects were able to accurately remember the original colour of the pitcher (green), on what basis would they *deliberately* compromise this hue, with typical knowledge that pitchers are yellow?

A blending hypothesis is useful in that it can account for all of the empirical data; or more accurately, none of the studies carried out can *discount* a blending explanation. Within the standard recognition test paradigm (e.g. Loftus et. al, 1978), it might be assumed that the memory for the items is a blend and that subsequent response is a matter of selecting the closest match to this blend representation. Under certain retrieval conditions, one or other of the items or features[1] associated with that item may be made more salient than the other; if so, this item is selected. The modified test procedure (e.g. McCloskey & Zaragoza, 1985a), by not allowing the possibility of selecting the misleading suggestion, clearly weights response choice towards the original event item. In the yes/no tests employed by Tversky and Tuchin (1989), misled subjects often responded 'yes' to both the original *and* the misleading item, without seeing any contradiction in their responses; the memory therefore could be conceptualised as containing aspects of both items (although the alternative that *both* items exist separately would equally support this finding).

Theoretical support for a memory integration hypothesis comes from the growing number of memory models which have as their central tenet the concept of composite storage (e.g. Eich, 1982; McClelland & Rumelhart, 1986; Anderson & Hinton, 1989). In these models representations from successive events are superimposed on one another and stored as collective patterns of 'neural' networks. One such model is Eich's (1982) composite holographic associative recall model, or CHARM, in which the concept of memory blending falls out as a natural prediction of the model:

> "When two unrelated target items (B & D) have been associated with the same cue (A) and both associations have been stored in the composite trace, when the cue is correlated with the trace, the

---

[1] Features may not necessarily correspond to eyes, nose length, edges, bars, etc., but are assumed to be 'abstract' in nature and not obviously related to the item in question (e.g. see Metcalfe, 1990).

> single item that is retrieved is a combination of both of the unrelated targets."
>
> (p. 683)

A basic outline of the model is as follows: Items are represented in terms of vectors of features (which may be abstract in nature). Two items are associated together by means of the operation of convolution which roughly equates to associating all the features of one item with all the features of the other item. A "higher-order" composite trace results, which does not resemble, in any obvious way, either of the contributing items; numerous other associations may be added to this composite trace. Retrieval occurs by correlating the retrieval cue with the composite trace to obtain the associated item. This item is matched to each item in the lexicon; if the 'resonance' value or 'feature convergence' is above criterion level the item will be retrieved (this explanation is unavoidably brief - see Eich, 1982, 1985, for a more detailed account and accompanying mathematical proofs). In terms of the blending hypothesis, if two different items have been convoluted with the same cue, the single retrieval vector will match both the associated items. Subsequently, if these items are on some kind of psychologically plausible, continuous scale there may be another (blended) item which is a better match than either of the two separate components (Metcalfe, 1990).

In a series of simulations (Metcalfe, 1990) the CHARM model neatly accounts for the empirical data of a wide range of experiments, including the original Loftus et. al (1978) design, the modified recognition test employed by McCloskey and Zaragoza (1985a), yes/no testing procedures (Belli, 1985; Tversky & Tuchin, 1989), as well as the blend memory experiments of Loftus (1977). The results of these experiments fall out naturally in the simulations; as Metcalfe (1990) states:

> "In the context of the model, one would say that the item retrieved from the composite memory trace may be a superimposition, but if no such entity exists as a lexical entry, then the model will be forced into an either/or or both decision."
>
> (p. 156)

A recent article by Metcalfe and Bjork (1991) in response to debate over the usefulness of CHARM (Lindsay, 1991; Schooler & Tanaka, 1991), recants the blend prediction of CHARM, or at least reduces it to an isolated possibility rather than a mandatory prediction of the model. Metcalfe and Bjork go on to suggest that in some cases a separate-trace model may also predict blended-response outcomes. This debate is part of a wider issue (in the categorization literature) about whether information is represented in the form of summary prototypes (or integrated traces), or whether a separate trace, individual exemplar account is responsible for prototypicality effects and by extension blend responses. This issue, and the relation of the categorization literature to the misinformation effect is elucidated in the next section. Suffice to suggest at this point that these two, quite different, theoretical accounts are difficult to tease apart experimentally and often predict similar empirical results.

A summary of the theoretical accounts outlined above suggests that in view of experiments which prove that retrieval of the original item is possible under some conditions, it appears unlikely that the event information is overwritten or irrevocably lost. Similarly, although demand characteristics and response bias no doubt play a part in the misinformation effect it is unlikely that they can account for all the differences in responding between control and misled subjects. The finding that people fail to tag the source of their memories and the possiblity that information may be somehow integrated in memory lends support to a general, but as yet vague, hypothesis that subjects have blended representations of the different items, while different retrieval conditions may determine the saliency of the 'features' of any given item and influence subsequent response selection.

Wider Theoretical Issues

Psychologists (and philosophers) have often conceptualised memory as a veridical recall of previously stored items. All memories still exist and in pristine condition; all that is required for their recall is an appropriate retrieval environment. Greek philosophers analogised memory storage to imprinting in a wax tablet, with recollection seen as searching for an image in a corporeal substrate (see Kemp, 1991, for an overview of medieval and classical approaches). The putative limitless capacity of memory is extolled by Augustine: "Great is the power of memory, exceedingly great, oh my God - a large and boundless inner hall" (Augustine, cited in Hermann & Chaffin, 1988; p. 113). These medieval and classical approaches have quite a modern ring about them. Memory has often been conceptualised by cognitive psychologists as a 'storehouse' or 'filing system' in which items are stored, organised and can be 'found' (with the appropriate cue) at a later date. It is assumed that recall reflects a veridical recollection of previously experienced events; something like playing back a tape or video cassette (Loftus & Loftus, 1980, summarise these approaches).

In the real world memory does not operate like this; it is far more dynamic and malleable. Bartlett (1932) repudiated a 'storehouse' approach and suggested that memory recall is more a process of inference and reconstruction than simple retrieval of a stored item.

> "The first notion to get rid of is that memory is primarily or literally reduplicative or reproductive. In a world of constantly changing environment, literal recall is extraordinarily unimportant."
>
> (Bartlett, 1932, p. 205)

There are numerous examples in the autobiographical literature to suggest that people don't recall what *actually* happened but what they *think* happened. Furthermore, they may be unaware of the inaccurate nature of their memories (Jacoby, Kelley & Dywan, 1989). In addition, subjects in eyewitness memory experiments and in the courtroom are often as confident when they are wrong as when they are correct (e.g. Schooler et. al, 1986). Jacoby et. al (1989) suggest that memory is an inference about the past and at a subjective level is similar to other affective reactions in its reliance on attributional processes.

Bartlett (1932) emphasized the creative or reconstructive aspect of memory and suggested that:

> "... every normal individual must carry about with him an incalculable number of individual traces. Since these are all stored together in a single organism, they are in fact bound to be related one to another, and this gives recall its inevitably associative character."
>
> (p. 197)

This quote has a prescient similarity to the approach adopted by a number of connectionist models of learning and memory. Connectionist models (e.g. McClelland & Rumelhart, 1986) postulate that information is not stored anywhere as such, but rather it is represented in the relationship among units (which are roughly analogous to neurons). Information therefore is stored in a distributed fashion and retrieval processes are characterised as an evocation of a previous pattern rather than a retrieval of appropriate items. Retrieving information is seen as analogous to tuning into a particular frequency. Although connectionist approaches have their limitations (e.g. Norman, 1986; Schacter, 1989) they are useful in that generalization, revision and inference are inherent properties of the system. Although information is 'stored' as particular events, these events are represented in the form of a composite trace which yields generalizations of particular instances even though the generalizations are never stored directly. This account is useful for cutting across a central debate in the classification literature as to whether people represent categories by storing individual exemplars (e.g. Medin & Schaffer, 1978; Hintzman, 1986; Nosofosky, 1991) or as unitary abstract representations or prototypes (e.g. Tulving, 1983). Memory blends, as found in the eyewitness memory literature, are seen as the "beginnings of the formulation of a summary representation and fall naturally out of distributed models" (McClelland & Rumelhart, 1986, p. 208). Experimentally, however, it is very difficult to tease apart exemplar and prototype models. The finding that subjects will recognize or select a blend item more quickly or over and above previously seen items of which it is constituted is commensurate with both an exemplar and a prototype approach.

Watkins (1990) suggests that the problem in discriminating between different theoretical approaches is a more fundamental one; that is, they all rely on the erroneous belief in a memory 'trace' or 'representation'. By eschewing the notion of traces, Watkins suggests that memory can be studied in terms of the actual experiences of remembering and the context in which remembering occurs. However, all he really suggests is that because we can't know what is happening (in the brain) in the interim between exposure to information and subsequent recall, we should therefore ignore all questions of storage and consequently 'traces'. His vitriolic is, in a way, more reasonably aimed at a subsection of brain scientists exclusively studying changes at a synaptic level, rather than cognitive psychologists who place considerable emphasis on environmental conditions and associated contextual parameters (e.g. Tulving, 1983). Although it is assumed that the trace or engram is a metaphor for an as-yet-fully understood physiological and mentalistic process, it is difficult to completely remove the concept of memory representation without resorting to Skinnerian accounts of the mind. As Tulving (1991) points out:

> "When an event occurs that a person perceives and subsequently remembers, some changes must occur in the brain. That is, the brain is different before and after that event. We can call that before-after difference the engram, or the memory trace, or the representation of the event or whatever."
>
> (p. 89)

He goes on to add that the engram does not exist independently of retrieval processes, i.e. the engram is an entity that can only manifest itself in retrieval activity. This engram-retrieval relationship he terms 'synergistic ecphory' which places emphasis on the type of cue and contextual conditions at the time of retrieval. Although it *is* hard to know exactly what 'traces' are, I would argue that this is not necessarily a good reason for completely ignoring them, or denying their existence.

It would seem that we know more about what memory isn't than what it is. The idea that information is unlimitlessly 'stored' or 'filed away' accurately for veridical retrieval is clearly erroneous; memory retrieval can be conceptualised as both creative and reconstructive. Although (as Watkins points out) we can't *know* what is exactly in memory, in terms of theoretical parsimony (and known physiology of the brain) I think it reasonable to assume that information may be represented in terms of 'dynamic composite traces', which can yield blended or prototypical type responses under certain retrieval conditions. Further evaluation of any theoretical model certainly requires corresponding advances in explorations of experimental variables and associated contextual information analysis.

Overview of the experiments

As mentioned previously, an 'integration hypothesis' which posits either a blend representation of event and post-event items in memory or an integration of those (separate) items at the time of retrieval can account for the wide range of results found in the eyewitness memory literature. Examples explicitly designed to test the possibility of 'memory blending' by using stimuli on some kind of continuous scale are few; with the studies by Loftus (1977) and Belli (1988) as the only relevant examples. There are problems however with both these experiments in that they used recognition memory for colour as the dependent variable. As Metcalfe and Bjork (1991) point out, people probably have quite different subjective opinions of what exactly 'blue' or 'green' means to them in terms of specific hues. Furthermore, adaptation to the level of ambient light or small variations in the lighting conditions at event and test may have confounded the results in that the colour 'green' (or 'blue') at test might not precisely match the actual colour seen.

Metcalfe (1990) suggests faces can be represented on a continuous scale in terms of feature lengths and ratios etc., and are a potentially very important class of stimuli with respects to the yewitness memory literature. From an applied perspective witnesses recognition of faces plays a large part in suspect identification and subsequent conviction.

The current experiments were designed to allow the possibility of 'memory blend' responses by using schematic, computer generated line-drawings of faces. A caricature generator developed by S. Brennan (1985, cited in Rhodes, Brennan & Carey, 1987) allows the possibility of creating blended faces: Two faces are averaged together to form a third face - a mathematical average of the first two. Weighting the blend towards one of its components is also possible by adding one of the faces into the blend twice or more. It is possible therefore, to construct a continuous scale of faces which change in gradual increments from one face towards another.

Specifically two experiments were carried out using the misinformation effect paradigm to determine:

(1) Whether misleading, interpolated information will affect subjects' memory response for an original item, and
(2) Whether, when misled, subjects will select a blended (never before seen) item more frequently than either the original or misleading item.

If subjects are impaired in their ability to recognize an original face after the presentation of an interpolated face, this would support the legion of evidence demonstrating such misinformation effects. If a blend face is selected more frequently than the other choices (by misled subjects) support would be garnered for an integration or memory blending hypothesis, as well as adding empirical support to a number of theoretical models, which predict composite storage, or integration during retrieval processes.

Experiment 1

The hypotheses of this experiment are as follows: Control subjects are expected to select the original face significantly more than misled subjects, while misled subjects are expected to select the blended face more often than control subjects and more often than the other faces presented, including the original face.

Method

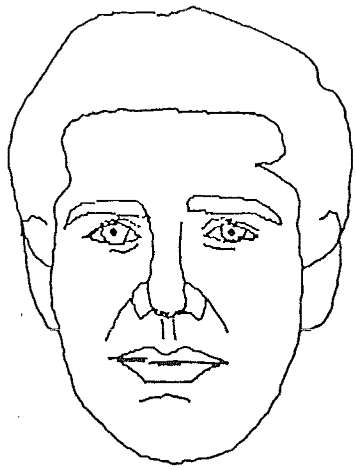
Subjects:
207 Stage 1 psychology students participated as part of a laboratory class: 105 subjects in the misled condition and 102 subjects in the control condition.

Stimuli
The stimuli used in Experiment 1 consisted of a series of 21 cartoon-like slides, along with six slides of computer generated line-drawings of faces. There were four slides of individual faces and two test slides comprised of four faces each. The faces were produced by a caricature generator which uses digitized photographs of people's faces to produce line drawings. Overall two sets of faces were used. The faces consisted of veridical line drawings based on photographs of members of the Stanford University psychology department and two faces which represented mathematical averages of the two different faces used in each of the stimuli sets. The caricature generator creates the averaged faces by comparing each of 169 points of the two different faces and taking the intermediate or mean position on each point between the two faces to construct the third, averaged face (examples of the stimuli used in Experiment 1 are shown in Appendix 1).

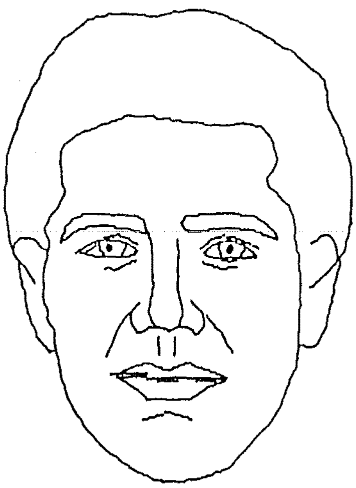
Design and procedure:
Subjects were tested in their laboratory class in groups of 25-30; they were told that they would be presented with a series of slides which they should pay close attention to, as they might be tested on some of the items.

A series of 12 black and white cartoon-like slides depicting the theft of a wallet were shown for 4 seconds each. A computer technician was seen entering a room, examining a broken computer terminal, fixing the terminal, then spying a wallet on the table, putting that wallet in his bag, and leaving the room. The critical slide embedded in this sequence was that of a computer generated line-drawing of a male face: the technician in question. All subjects then participated in a two minute filler activity (reading a story). A further nine slides were shown continuing the sequence of events - the technician leaves the building by means of an elevator and drives off in a vehicle parked outside the building. The 105 misled subjects received a further slide depicting a *different* (but similar) computer generated face, assumed to be the technician. The 102 control subjects did not receive this additional slide. Two different pairs of faces were used and were counterbalanced so that each face was equally often seen as the original or interpolated item. After a further two minute interval subjects were shown a single slide of four faces (see Figure 1). The slide compromised of: (1) the original face, (2) the interpolated face, (3) a blend of these two, and (4) a completely novel face. Subjects were asked to select which face looked most like the computer technician depicted in the first set of slides that were shown.

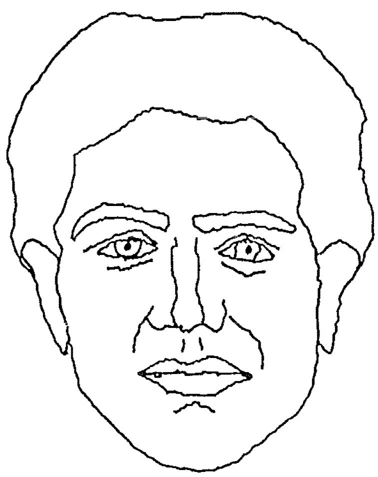
Example of Faces used In Expt 1.



Bob.



BLEND.



Brian.

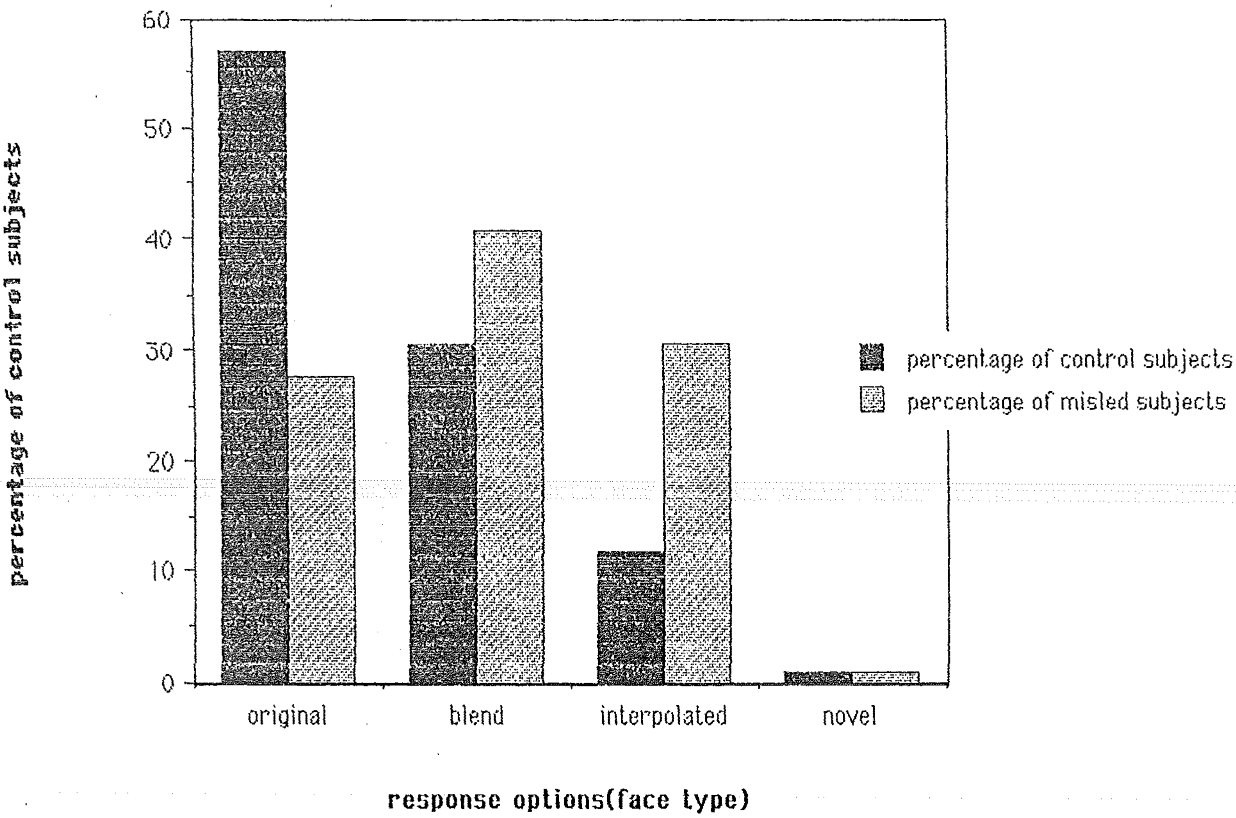
Results

As can be seen in Figure 2, 56.86% of control subjects selected the original face whereas 30.40% selected the blend face, 11.76% the interpolated face (which wasn't viewed by control subjects) and 0.98% selected the novel face. In comparison to these results the most frequently selected face for misled subjects was the blend face (40.95%), followed by the interpolated (30.48%) and the original (27.62%) face. The novel item was only selected by 0.95% of the subjects. Calculations of significant differences between proportions for the two groups revealed that the control subjects more often selected the original face as compared to misled subjects [$z(207)=4.51$, $p<.05$] whereas misled subjects were more likely to select the interpolated item than were control subjects [$z(207)=1.61$, $p<.05$]. Although more misled subjects (40.95%) selected the blend face than did control subjects (30.40%) this difference was not significant [$z(207)=1.61$, $p<.05$] (see Appendix 2 for details of analyses).

Discussion

Overall, the basic misinformation effect was reproduced. Subjects who had been presented with an interpolated item were subsequently impaired in their selection of the original item as compared with controls. While the blend item seemed to be the *most* favoured by misled subjects, a large number also selected the interpolated and original item. The finding that control subjects did not differ significantly in their selection of the blend item from misled subjects was a little surprising, although it probably reflects the similarity between the blend and original item, and the wider dispersion of responses among the three main items in the misled group. One other possible reason why the blend is 'recognized' so readily is that it may be less *distinctive* than the other faces. Recent research suggests (e.g. Valentine & Bruce, 1986) that while highly distinctive faces are recognized more quickly than less distinctive faces, average faces are more often erroneously recognized; that is, subjects are more likely to say they have seen a never-before-presented, typical face than a non-typical face. Perhaps also, a wider range of blend choices might reveal the kind of selection shift found in the Loftus (1977) experiment. The second experiment was designed to evaluate these possibility and to collect the additional measures of face typicality and confidence in responding.

Fig. 2: Percentage of control and misled subjects who selected each response option in Experiment 1.



Experiment 2

Method

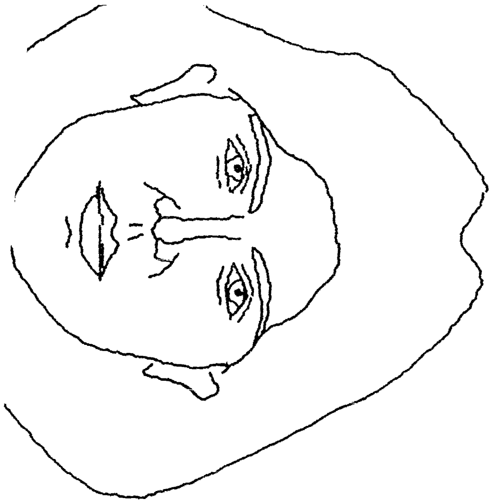
Subjects

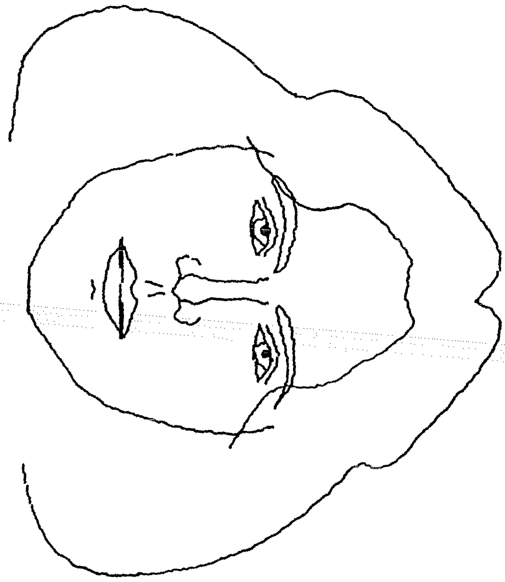
30 subjects with ages ranging from 17 to 25 participated voluntarily in this experiment.

Stimuli

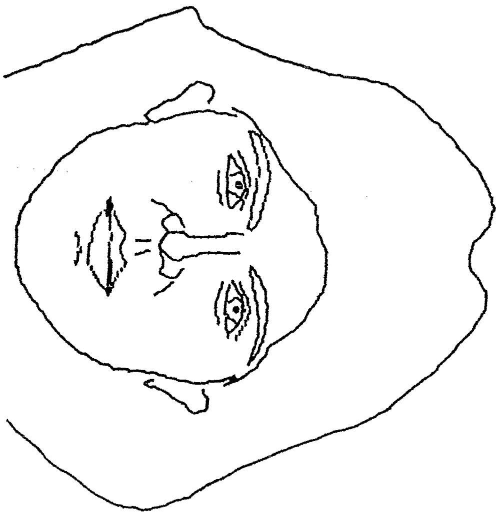
The stimuli in Experiment 2 consisted of two sets of nine faces, all produced using the caricature generator described in Experiment 1. For each experimental condition there were eight slides of individual faces, four with names written underneath and four with the names blanked out, and one slide which consisted of six faces which represented the novel, original, misleading and blend alternatives. A continuum of blend faces from the original to the misleading face was constructed by weighting two of the blend faces to either the original or misleading face. This continuum is illustrated in Figure 3.

Examples of stimuli used in Experiment 2. The numbers in brackets represent the percentage of the original face present in the face.

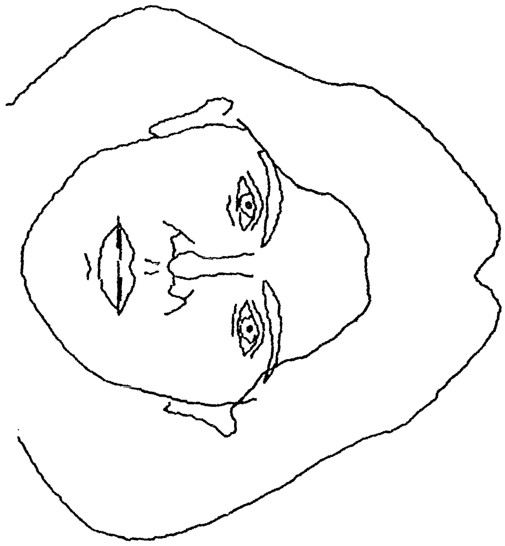




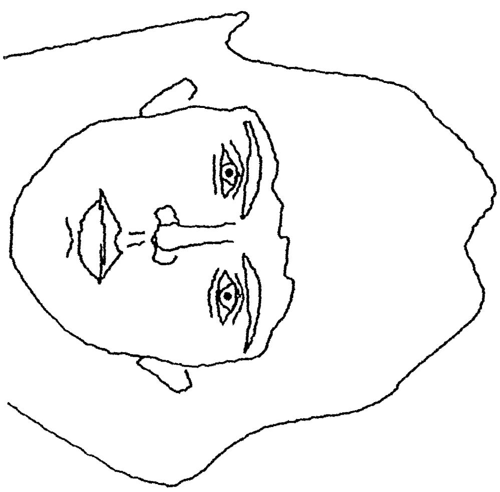
Jane (0)



(67)



(33)



Jenny (100)

Design and procedure:

All subjects participated in separate control and misled conditions and were counterbalanced so that half of the subjects participated in the control condition first and half of the subjects participated in the misleading condition first. Subjects were told that the experiment involved viewing a number of faces which they should pay close attention to as they may be asked to recognize them later. Initially four slides of computer-generated schematic faces with names written underneath were shown for 4 seconds each. The faces were either all male or all female within a single block. Subjects were told that "these are four people whom you meet at a party". After a two minute interval in which the experimenter chatted with the subjects, subjects either received audibly (at 4 second intervals) the four names of the subjects viewed previously or else received four more faces, with the names blanked over but read out at the presentation of each slide. Three of these slides were of the same faces seen in the first section, while a fourth was a different face but tagged with the same name as the original slide. This misleading slide and its original counterpart were counterbalanced so each face was presented as either the original or the misleading face an equal number of times. After a further two minute interval subjects were shown a single slide which consisted of six different faces. The faces comprised of (1) the original (100), (2) a blend between the original and misleading face weighted two times in favour of the original (67), (3) a blend between the original and misleading face (50), (4) a blend weighted two times in favour of the misleading face (33), (5) the misleading face (0), and (6) a novel face. The ordering of the faces on the slide was random and counterbalanced so that each face was seen (roughly) equally often in each position. Subjects were asked "which face (A, B, C, D, E or F) looks most like the person _____ [name of the original face presented] depicted in the first set of slides? (If you can't remember the name of the person simply select the face which looks most like (the) one which you viewed in the first set of slides)." Subjects were also asked to supply an indication of how confident they were with this selection on a seven point scale: 1, being not confident at all, 7 being very confident. Finally subjects were asked to rate (on a seven point scale) each face on distinctiveness: 1 being an undistinctive face, 7 being a very distinctive face. Distinctiveness was described as how easy the face would be to pick out from a crowd.

Results

For analysis each possible response face was given a number reflecting the proportion of the original face in the item, so that 0 represented the misleading face, 33 the blend face weighted in favour of the misleading face, 50 the average blend face, 67 the blend face weighted in favour of the original face, and 100 the original face. This enabled a comparison of mean responding between the control and misled group. The mean selection of the 30 control subjects was 73.93, whereas the 30 misled subjects produced a mean of 49.50. This difference was significant: $t(29)=3.38$, $p<.01$. Thus the introduction of the misleading face significantly affected a group of subjects in their recognition selection of the original viewed item. The distribution of responses (Figure 4) illustrates that misled subjects' shifted their preferred selection towards the equal blend face as compared to controls. While 43.39% of control subjects selected the original face only 13% did so from the misled group. Conversely, 30% of misled subjects chose the equal blend as compared with 16.67% of controls. In fact, the mean selection response for misled subjects did not differ significantly from the number represented by the blend face (50): $t(29)=0.088$, $p>.05$, whereas the control subjects' responding did not differ significantly from the blend item weighted towards the original face (67): $t(29)=1.44$, $p>.05$; but did differ from both the blend item (50): $t(29)=5.18$, $p<.01$, and the original face (100): $t(29)=5.62$, $p<.01$. Analysis of the confidence ratings revealed that subjects were significantly more confident in the control group as compared to misled subjects: $t(29)=2.78$, $p<.01$. The typicality ratings, analysed using repeated measures t-tests, revealed that the blend faces in all but one case were rated as significantly more 'typical' than either of the two faces of which they comprised (see Table 3). The relation of these results to response selection are discussed more fully in the general discussion below.

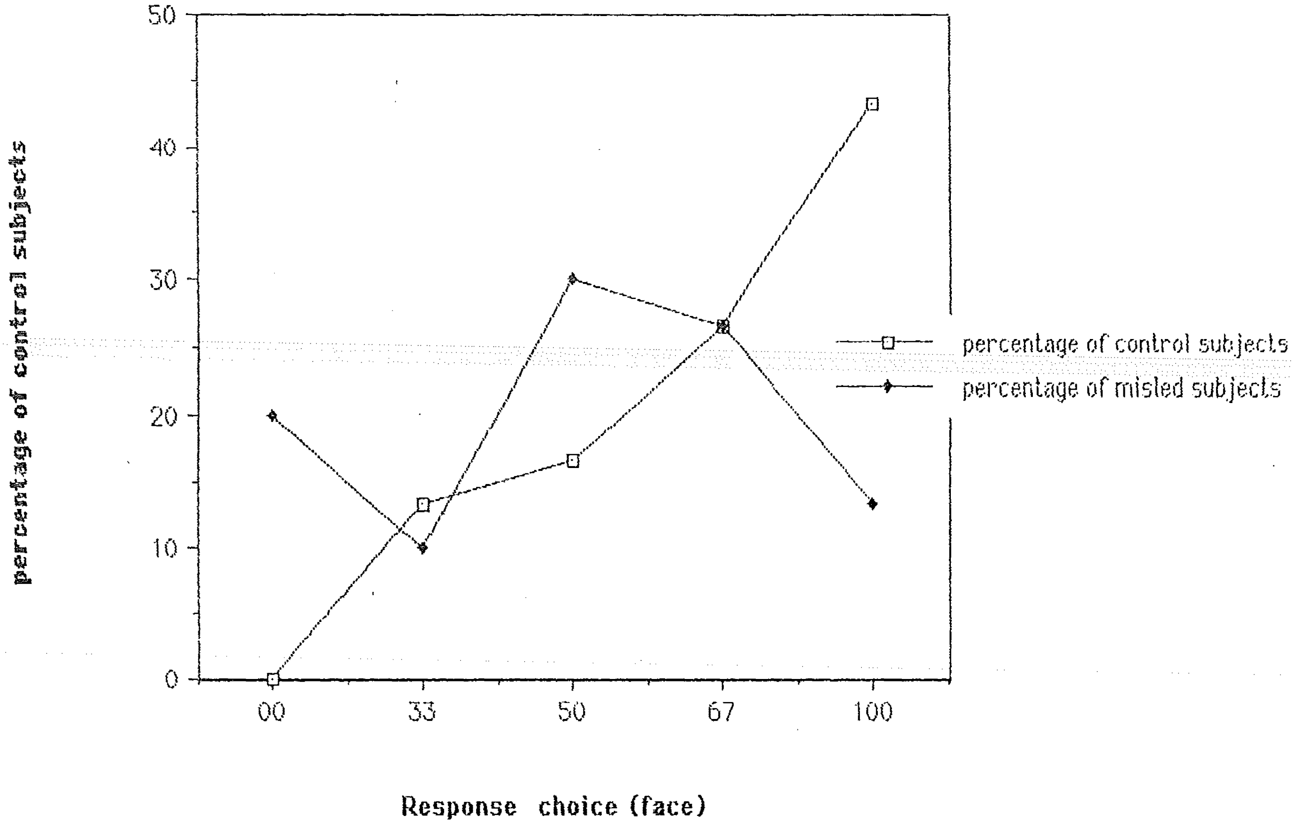
Face	Face Set 1	Face Set 2
A	3.40	4.93*
AAB	3.50	4.30
AABB	3.77*	3.97*
ABB	3.77	4.30
B	4.60*	4.60*

(1 = low distinctiveness; 7 = high distinctiveness)

* $p<.05$

Table 3: Mean typicality ratings for face stimuli used in Experiment 2.

Fig. 4: Percentage of control and misled subjects who chose each response option in Experiment 2.



Discussion

The main misinformation effect was again replicated in Experiment 2. Subjects who had been exposed to misleading information, in the form of interpolated faces, were less likely to select the original face and opted instead for a blend item which consisted of both the original and misleading faces. The finding that misled subjects were less confident about their selection choices than were control subjects was probably due to the increased difficulty in selecting the appropriate face in the misled condition. Misled subjects had a selection of six faces, all of which were very simlar o(and two the same as) previously viewed items. Subjects in the control group, by not viewing the misleading face had less faces which were familiar only one of the faces was viewed before with the other faces gradually decreasing in similarity from this face.

The finding that the blend faces were rated as more typical than their constituents was not surprising; presumably blend faces are more 'average' and thus overall less distinctive than individual exemplars. Although, as discussed below, the difference in typicality can not adequately account for why only subjects in the misled condition and not the control condition preferred the blend option.

General Discussion

The results of both experiments show effects of misleading or interpolated material on memory for an original event. Subjects who received misinformation in the form of schematic faces which differed from the originally presented faces were subsequently impaired on a recognition test in that they were less likely to select the face which was originally presented. The experiments replicate the findings of numerous studies in the field, and more specifically, studies by Gibling and Davies (1988) and Jenkins and Davies (1985), who also employed face stimuli to find a misinformation effect.

The finding that misled subjects were as, or more, likely to select the blend face over the other alternatives replicates the previous studies carried out on blending (using colour stimuli) by Loftus (1977) and Belli (1988). The shift in response selection from the original face to the blended one was most clearly illustrated in Experiment 2: Overall 66.67% of misled subjects chose one of the three blended options with only 13.33% selecting the original face. While the blended items were also popular for control subjects (56.67%) significantly more subjects chose the correct original item (43.39%) than in the misled group.

How do we account for these results within the framework of theoretical options delineated earlier? -

<u>Demand characteristics</u>

Perhaps misled subjects remembered both event and post-event faces and chose the blend item as a deliberate compromise selection; that is, their response reflected a desire to be at least partially correct. Although it is impossible to completely rule out the possibility of demand characteristics it seems highly unlikely that subjects could retain a veridical representation of both items in memory so that they could consciously select a blend item in between the two. Face *recall* as such is notoriously difficult and probably only eidetic imagers could consciously select a compromise option even if they realised that one or more of the faces presented represented a blend of two of the previously viewed items.

Response bias

According to this argument (e.g. McCloskey & Zaragoza, 1985a) subjects should perform more poorly in the misled condition for non-memory reasons. While control subjects who 'forget' the original item select an option at chance level, misled subjects (who forget the event information) are biased into selecting the misleading alternative. Clearly this argument can't explain why misled subjects preferred a blended item over the misleading one. If they forget the original information then the misleading item should be more frequently chosen. As this was not the case, response bias is unlikely to play a part in the pattern of results which were found.

Overwriting/destructive updating

Although this idea probably has little credence in the literature anyway, the finding that misled subjects select the blend item quite frequently implies that at least some aspects or 'features' of the original face are present in the system. It is unlikely then that the new, interpolated material completely overwrites or updates a previously presented item.

Source misattributions

According to the source misattribution hypothesis, subjects retain one or both items of information but are unsure of the *source* of their memory. The short retention intervals, and the similarity between event and post-event environments in the two experiments probably facilitates the possibility of source errors. Although in the second experiment the post-event slides had blanked out names which were read out as opposed to being viewed in the event, this might not have been enough to accurately discriminate between the two sources. Brown, Deffenbacher and Sturgill (1977) found that face recognition was much better than recall of the *source* of the familiarity; as Jacoby et. al (1986) point out, familiarity does not specify its source, but rather the source is attributed to a particular situation depending on the nature of the experimental environment. Although source mistakes probably did occur in this experiment, they still can't adequately account for the blend preference effect. If subjects were unsure of the source of their memory (be it an event or post-event item) on what basis would they select a never-before-seen blend over either of the previously viewed items?

Typicality

One possibility, as noted in the results section of Experiment 1, is that if typical faces are more likely to be erroneously recognised as items seen before than non-typical faces, perhaps the blend selection can be explained in terms of the typicality of the blend face. Although the a posteriori distinctiveness ratings do indicate that the blend faces were rated as more typical than their constituents, a preference based entirely on typicality can't explain why control subjects significantly more often chose the original face (56.9% in Experiment 1) over the blended item (30.40%). In the second experiment although the blend faces were selected quite frequently by control subjects, the original item was chosen (43.39%) more often than the equal blend (16.67%) or the blend weighted towards the original item (26.67%). While typicality can't be ruled out as a basis for selection in the misled group, the control subjects seemed to base their selection in both experiments on the similarity of the item to the original face and not to the most typical one.

Coexistence/Integration

The most parsimonious explanation of blend memory results is that information is either integrated in memory to form a unitary representation of the two different items, or else the two pieces of information reside separately and are blended together at the time of retrieval. A third alternative is that the different items reside separately in memory with subsequent recognition judgements being based on the overall summed similarity of the separately residing exemplars. An examination of the classification literature is useful for evaluating the viability of these three options. Although the number of stimuli may be too small to be commensurate with normal categorization studies, at the very least, blend memory results can be indicative of the beginnings of summary representation type phenomena.

A prototype approach would favour the idea that the two different faces are blended together in memory to form a prototype face which is subsequently selected on recognition tests. It should be noted however that Valentine and Bruce (1986) believe that there is only *one* face prototype which cannot really be manipulated during psychology experiments. However, Valentine and Bruce (1986) failed to supply any empirical support for this idea and there seems no reason why a prototype face cannot be formed on the basis of a limited number of exemplars and in the context of a single experiment. An exemplar approach, in contrast to a prototypical account, assumes that each event gives rise to distinct and different episodic traces, with abstract knowledge (e.g. blends) being derived from the pool of traces of these events or experiences, at the time of retrieval (Hintzman, 1986). An exemplar approach as espoused by Nosofsky (1991) seems useful in capturing the important aspects of the current experimental findings. Nosofsky postulates that:

> "People represent categories by storing individual exemplars in memory, and make classification [or recognition] decisions on the basis of similarity comparisons with the stored exemplars."
>
> (p. 3)

Recognition decisions therefore are based on the absolute summed similarity of any given item to all 'stored' exemplars.

> "This absolute summed similarity gives a measure of overall familiarity with high familiarity values leading to higher recognition probabilities."
>
> (Nosofsky, 1991, p. 3)

The results of both Experiment 1 and 2 illustrate this theoretical idea quite clearly: For control subjects (in Experiment 2) the original item (e.g. the face 'Jenny') is closest in similarity (not surprisingly) to the originally viewed face 'Jenny'. Assuming some 'noise' in the system recognition performance is not perfect (43.39%). The next closest item in terms of similarity is the blend face which comprises of two 'Jennies' and one 'Jane'; this blend was selected the next most often (26.67%). The equal 'Jenny/Jane' blend was the next most popular (16.67%), while the blend weighted in favour of 'Jane' was selected by 13.33% of subjects. The face 'Jane' and the novel item (which were dissimilar to 'Jenny') were not selected at all. For misled subjects the item which was most similar to all (both) of the stored exemplars was the equal blend, which was selected the most often (30%). The other two (weighted) blends were the next most similar items; overall being selected by 36.67% of subjects, with the actually viewed items being selected by a combined 33.33% of subjects. The distribution of selections in the misled condition were naturally more spread and no doubt other variables such as the relative 'accessibility' of the various items influences overall similarity judgements.

Although the usefulness of adopting a exemplar based model is most clearly seen within the context of blend experiments, it could also account for more general findings in the misinformation effect literature. Consider the Loftus et. al (1978) experiments: subjects with memory 'traces' for both the stop and give way sign (i.e. misled subjects) base their final recognition decision on overall similarity between the two alternatives presented at the test and the two items present in the experiment. Assuming only one item can be correct the subject selects the give way sign because it involves a higher overall recognition 'signal' (perhaps because the information is more recent, or more *salient*). In the design employed by McCloskey and Zaragoza (1985a), the original item (screwdriver) is preferred by both control and misled subjects; it is certainly more similar to previously encountered item(s) than a completely novel item (wrench). Where possible (e.g. Tversky & Tuchin, 1989) subjects may well select *both* original and misled items if they both reach 'criterion' similarity levels and the choices are reasonable with regards to the experimental context.

Although a summed similarity model may be the most parsimonious account for explaining the results found in eyewitness memory experiments, both prototype and exemplar models could be similarly used to account for the same experimental findings. Indeed, it may be impossible to tease apart these three options empirically.

Experimental extensions

Whereas experiments designed to differentiate between the three theoretical options outlined above are difficult to conduct, the extent of blend responding found may differ under different experimental conditions. For example, manipulating retention intervals and the discriminability between the two sources of information may decrease (or increase) the degree of blend responding found. That is, if subjects can actively tease apart the source of their memories, by use of explicit warnings and/or high discriminability between the event and post-event faces, perhaps the saliency of the subsequently presented blend faces, in terms of performance on a recognition test, would be decreased. If subjects still select blend responses even when source is clearly delineated, this may tell us something about blending processes in general (they could be an implicit aspect of brain systems) and face recognition in particular (that it is source independent).

The presentation of different but not *misleading* faces within a particular experimental environment may well lead to innocent bystander effects: With the non-target or indeed blend faces being selected as, or more often than, the target item. This finding would be interesting from an applied perspective: If people are happy to integrate information from different faces derived from the same source, erroneous identification of suspects might occur.

The possibility that subjects base all recognition decisions on summed similarity to stored exemplars suggests that manipulations in similarity among faces presented may influence subsequent responding. If the original and interpolated face are highly similar the distribution of responses should be more spread out; assuming that the two items and all the blends look very much alike. When similarity between event and post-event faces is quite low, the two 'end' faces in a blend continuum maybe chosen somewhat less frequently. Although highly disparate items would probably enable subjects to pick up the discrepancy and therefore 'ignore' the misleading item. Certainly the use of face stimuli (as realised by the caricature generator) offers a wide range of experimental manipulations and further research is probably necessary to fine tune the type of theoretical explanations used to account for the data in these and other experiments.

Applied perspectives

While the major thrust of this paper and indeed the majority of the eyewitness memory literature is primarily theoretical in nature, the experiments demonstrating misinformation effects have obvious real world applications. The early Loftus experiments by utilizing more 'naturalistic' experimental settings, aimed in part to evaluate the veridicality of courtroom testimonies. The finding that subjects will, under conditions roughly analogous to real-world testimonies, report information presupposed but not seen (and be confident in those reports) casts doubts on the reliability of eyewitness testimonies.

Although it has been argued by some (see Goodman & Loftus, 1989) that experimental studies are not applicable to the real world, Loftus and Goodman (1989) suggest:

> "What is generalisable to real-world settings is not so much the specific findings of a given variable in a given study, but the processes underlying that variable."

In other words a realisation of the theoretical mechanisms underpinning misinformation effects can be useful in attempting to increase the efficacy of courtroom testimony.

One area that has received considerable experimental interest and is critical in eyewitness reporting is that of face recognition (see Laughery & Wogalter, 1989, for a meta-analysis of over 100 studies). Several important variables seem to determine the accuracy of face recognition: Retention interval, intervening faces, and context. Face recognition, like most aspects of memory performance, decreases in accuracy with increasing retention intervals. Although recognition ability seems to be relatively stable up to a two-week period (Davies, 1989), recognition performance begins to decline sharply at longer retention intervals. The implications for eyewitness procedures are clear: subjects should be involved in identifying the suspect face in question as soon as possible. Another quite robust finding, and one supported by the current experiments, is that identification accuracy decreases as the number of intervening faces increases and as the similarity among the faces increases.

Numerous studies (e.g. Brown et. al, 1977; Gibling & Davies, 1988; Jenkins & Davies, 1985) have found erroneous reporting of interpolated faces (assumed to be the suspect) which were not originally viewed in a crime sequence, but were later presented in the form of mug-shots or photo spreads. In addition to this, Loftus (1976; cited in Laughery & Wogalter, 1989
) found that a face may be wrongly selected if it was exposed near it time to the event: the so-called innocent bystander effect. These studies highlight the difficulty in attributing source to previously viewed faces; with overall familiarity seeming to be the main criterion for recognition selection. It is important, as Davies (1989) points out, that the witness at the parade not only recognises a suspect as familiar but also can locate them in the appropriate context.

One important variable which seems to increase the accuracy of face recognition is context reinstatement. As with other areas of memory research, reinstating the context of the original environment facilitates subsequent memory performance. Cutler and Penrod (1988) in a meta-analysis of context reinstatement studies suggests that there is a large effect of context on subsequent recognition for faces which is most apparent when the memory for to-be-remembered face is impaired.

The studies carried out on face blending presented in the present paper illustrate the difficulty of face recognition when source and context cues are unavailable and when intervening faces (similar to the target) precede a recognition test. The main factors which should be taken into account in real-world situations are: Firstly, a realisation of the possible inaccuracy of face identification; secondly, the usefulness of source cueing through context reinstatement; and thirdly, the importance of obtaining as much information about the suspect's face from the witness *prior* to looking at photo spreads or mug files.

Conclusion

A general distillation of the eyewitness memory literature reveals one major, but important, finding: when post-event information is presented to subjects in one form or another their subsequent memory reporting for original information is impaired. The wider implication of this finding is that memory is not a veridical, 'stenographic' process, but one which probably has reconstructive and inferential properties as central to its functioning. The finding that subjects, who have been presented with interpolated faces, will select a blended face option (on a recognition test) more frequently than alternatives actually presented lends support to a loosely connected farrago of theoretical models. Distributed models of memory that postulate 'composite trace' storage capture the essential elements of individual trace integrity along with an abstraction of object or concept from the overlay of similar items. An exemplar approach to recognition in which items are judged as 'familiar' on the basis of overall summed similarity to 'separately' stored exemplars is useful in capturing the central aspects of the results presented on face blending. Although a summed similarity model is perhaps the most parsimonious theoretical account, both a prototype and a separate trace retrieval integration model could also account for the type of misinformation effects found in the blending experiments. Variables operating at encoding and retrieval such as warnings and context reinstatement have been shown to attenuate the misinformation effect, probably in terms of reducing the saliency of post-event information and in effect precluding as a possible option on the subsequent recognition (or recall) test. The difficulty subjects have in making source attributions contributes to the overall misinformation effect, although the reporting of misinformation is probably not due entirely to source misattribution. Finally, eyewitness memory experiments which demonstrate the mutability of memory as illustrated by erroneous reporting of misleading items have important applied applications. The accuracy of witness identification can in some cases be questionable, especially when similar intervening items precedes subsequent identification.

References

Anderson, J.A., & Hinton, G.E. (1989). *Parallel models of associative memory.* Hillsdale: Lawrence Erlbaum.

Bartlett, F.C. (1932). *Remembering.* Cambridge: University Press.

Bekerian, D.A., & Bowers, J.M. (1983). Eyewitness testimony: were we misled? *Journal of Experimental Psychology: Learning, memory and cognition, 9,* 139-145.

Belli, R.F. (1988). Color blend retrievals: compromise memories or deliberate compromise responses? *Memory and Cognition, 16,* 314-326.

Belli, R.F. (1989). Influences of misleading post-event information: misinformation interference and acceptance. *Journal of Experimental Psychology: General, 118,* 72-85.

Bowers, J.M., & Bekerian, D.A. (1984). When will post-event information distort eyewitness testimony? *Journal of Applied Psychology, 69,* 466-472.

Brown, E., Deffenbacher, K., & Sturgill, W. (1977). Memory for faces and the circumstances of encounter. *Journal of Applied Psychology, 62,* 311-318.

Buckhout, R. (1974). Eyewitness testimony. *Scientific American, 231,* 23-31.

Chandler, C.C. (1989). Specific retroactive interference in modified recognition tests: Evidence for an unknown cause of interference. *Journal of Experimental Psychology: Learning, memory and cognition, 15,* 256-265.

Christiaansen, R.E., & Ochalek, K. (1983). Editing misleading information from memory: evidence for the coexistence of original and post-event information. *Memory and Cognition, 11,* 467-475.

Cole, W.G., & Loftus, E.F. (1979). Incorporating new information into memory. *American Journal of Psychology, 92,* 413-425.

Cole, P., & Pringle, P. (1974). *Can you positively identify this man? George Ince and the Barn Murder.* London: Deutsch.

Cutler, B.L., & Penrod, S.D. (1988). Context reinstatement and eyewitness identification. In G.M. Davies and D.M. Thomson (Eds.), *Memory in context: context in memory.* Chichester: John Wiley & Sons.

Davies, G.M. (1989). The applicability of facial memory research. In A.W. Young and H.D. Ellis (Eds.), *Handbook of research on face processing.* Amsterdam: Elsevier Science Publishers.

Eich, J.M. (1982). A composite holographic associative recall model. *Psychological Review, 89*, 627-661.

Eich, J.M. (1985). Levels of processing, encoding specificity, elaboration, and CHARM. *Psychological Review, 92*, 1-38.

Galton, F. (1883). *Inquiries into human faculty and its development.* London: MacMillan.

Gibling, F., & Davies, G. (1988). Reinstatement of context following exposure to post-event information. *British Journal of Psychology, 79,* 129-141.

Goodman, J., & Loftus, E.F. (1989). Implications of facial memory research for investigative and administrative criminal procedures. In A.W. Young and H.D. Ellis (Eds.), *Handbook of research on face processing.* Amsterdam: Elsevier Publishers.

Greene, E., Flynn, M., & Loftus, E. F. (1982). Inducing resistance to misleading information. *Journal of Verbal Learning & Verbal Behavior, 21*, 207-219.

Hermann, D.T., & Chaffin, R. (Eds.). (1988). *Memory in perspective, the literature before Ebbinghaus.* New York: Springer and Verlag.

Hintzman, D.L. (1986). "Schema abstraction" in a multiple-trace memory model. *Psychological Review, 93*, 411-428.

Jenkins, F., & Davies, G. (1985). Contamination of facial memory through exposure to misleading composite pictures. *Journal of Applied Psychology, 70,* 164-176.

Jacoby, L.J., Kelley, C.M., & Dywan, J. (1989). Memory attributions. In H.L. Roediger III and F.I.M. Craik (Eds.), *Varieties of memory and consciousness.* Hillsdale: Lawrence Erlbaum Associates.

Johnson, M.K. (1988). Reality monitoring: An experimental phenomenological approach. *Journal of Experimental Psychology: General, 117*, 390-394.

Kemp, S. (1990). *Medieval Psychology.* New York: Greenwood Press.

Laughery, K.R., & Wogalter, M.S. (1989). Forensic applications of facial memory research. In A.W. Young and H.D. Ellis (Eds.), *Handbook of research on face processing.* Amsterdam: Elsevier Science Publishers.

Lindsay, S.D., & Johnson, M.K. (1989). The eyewitness suggestibility effect and memory for source. *Memory and Cognition, 17*, 349-358.

Lindsay, S.D. (1990). Misleading suggestions can impair eyewitnesses' ability to remember event details. *Journal of Experimental Psychology: Learning, memory and cognition, 16*, 1077-1083.

Lindsay, S.D. (1991). CHARMed, but not convinced: comment on Metcalfe (1990). *Journal of Experimental Psychology: General, 120*, 101-105.

Loftus, E.F. (1977). Shifting human color memory. *Memory and Cognition, 5,* 696-699.

Loftus, E.F., & Loftus, G.R. (1980). On the permanence of stored information in the brain. *American Psychologist, 35,* 409-420.

Loftus, E.F. (1981). Mentalmorphises: Alterations in memory produced by the mental bonding of new information to old. In J. Long and A. Badderley (Eds.), *Attention and Performance IX.* Hillsdale: Erlbaum.

Loftus, E.F. (1979). Reactions to blatantly contradictory information. *Memory and Cognition, 7,* 368-374.

Loftus, E.F., Schooler, W., & Wagenaar, W.A. (1985). The fate of memory: comment on McCloskey and Zaragoza. *Journal of Experimental Psychology: General, 114,* 375-380.

Loftus, E.F., Donders, K., Hoffman, H.G., & Schooler, W. (1989). Creating new memories that are quickly accessed and confidently held. *Memory and Cognition, 17,* 607-616.

Loftus, E.F. (1975). Leading questions and the eyewitness report. *Cognitive Psychology, 7,* 560-572.

Loftus, E.F., Miller, D.G., & Burns, H.J. (1978). Semantic integration of verbal information into a visual memory. *Journal of Experimental Psychology: Learning, memory and cognition, 4,* 19-31.

Loftus, E.F., & Hoffman, H.G. (1989). Misinformation and memory: the creation of new memories. *Journal of Experimental Psychology: General, 118,* 100-104.

McCloskey, M., & Zaragoza, M. (1985a). Misleading post-event information and memory for events: arguments and evidence against memory impairment hypotheses. *Journal of Experimental Psychology: General, 114,* 1-16.

McCloskey, M., & Zaragoza, M. (1985b). Post-event information and memory: reply to Loftus, Schooler and Wagenaar. *Journal of Experimental Psychology: General, 114,* 381-387.

McClelland, J.L., & Rumelhart, D.E. (Eds.). (1986). *Parallel distributed processing, vol. 1 & 2.* Cambridge: MIT Press.

Medin, D.L., & Schaffer, M.M. (1978). Context theory of classification learning. *Psychological Review, 85,* 207-238.

Metcalfe, J. (1990). Composite holographic associative recall model (CHARM) and blended memories in eyewitness testimony. *Journal of Experimental Psychology: General, 119,* 145-160.

Metcalfe, J., & Bjork, R.A. (1991). Composite models never (well, hardly ever) compromise: Reply to Schooler and Tanaka (1991). *Journal of Experimental Psychology: General, 120,* 203-210.

Norman, D.A. (1986). Reflections on cognition and parallel distributed processing. In J.L. McClelland and D.E. Rumelhart (Eds.), *Parallel Distributed Processing, vol. ii.* Cambridge: MIT.

Nosofsky, R.M. (1991). Tests of an exemplar model for relating perceptual classification and recognition memory. *Journal of Experimental Psychology: Human perception and performance, 17*, 3-27.

Rhodes, G., Brennan, S., & Carey, S. (1987). Identification and ratings of caricatures: implications for mental representations of faces. *Cognitive Psychology, 19,* 473-497.

Schacter, S. (1989). Memory. In I. Posner (Ed.), *Foundations of cognitive science.* Cambridge: MIT Press.

Schooler, J.W., & Tanaka, J.W. (1991). Composites, compromises and CHARM: what is the evidence for blend memory representations? *Journal of Experimental Psychology: General, 120,* 96-100.

Schooler, J.W., Gerhard, D., & Loftus, E.F. (1988). Qualities of the unreal. *Journal of Experimental Psychology: Learning, memory and cognition,* 171-181.

Tulving, E. (1991). Interview with Endel Tulving. *Journal of Experimental Neuroscience, 3,* 89-94.

Tulving, E. (1983). *Elements of episodic memory.* New York: Oxford University Press.

Tousignant, J.P., Hall, D., & Loftus, E.F. (1986). Discrepancy detection and vulnerability to misleading post-event information. *Memory and Cognition, 14*, 329-338.

Tversky, B., & Tuchin, M. (1989). A reconciliation of the evidence on eyewitness testimony: comments on McCloskey and Zaragoza. *Journal of Experimental Psychology: General, 118,* 86-91.

Valentine, T., & Bruce, V. (1986). Recognizing familiar faces: the role of distinctiveness and familiarity. *Canadian Journal of Psychology, 40,* 300-305.

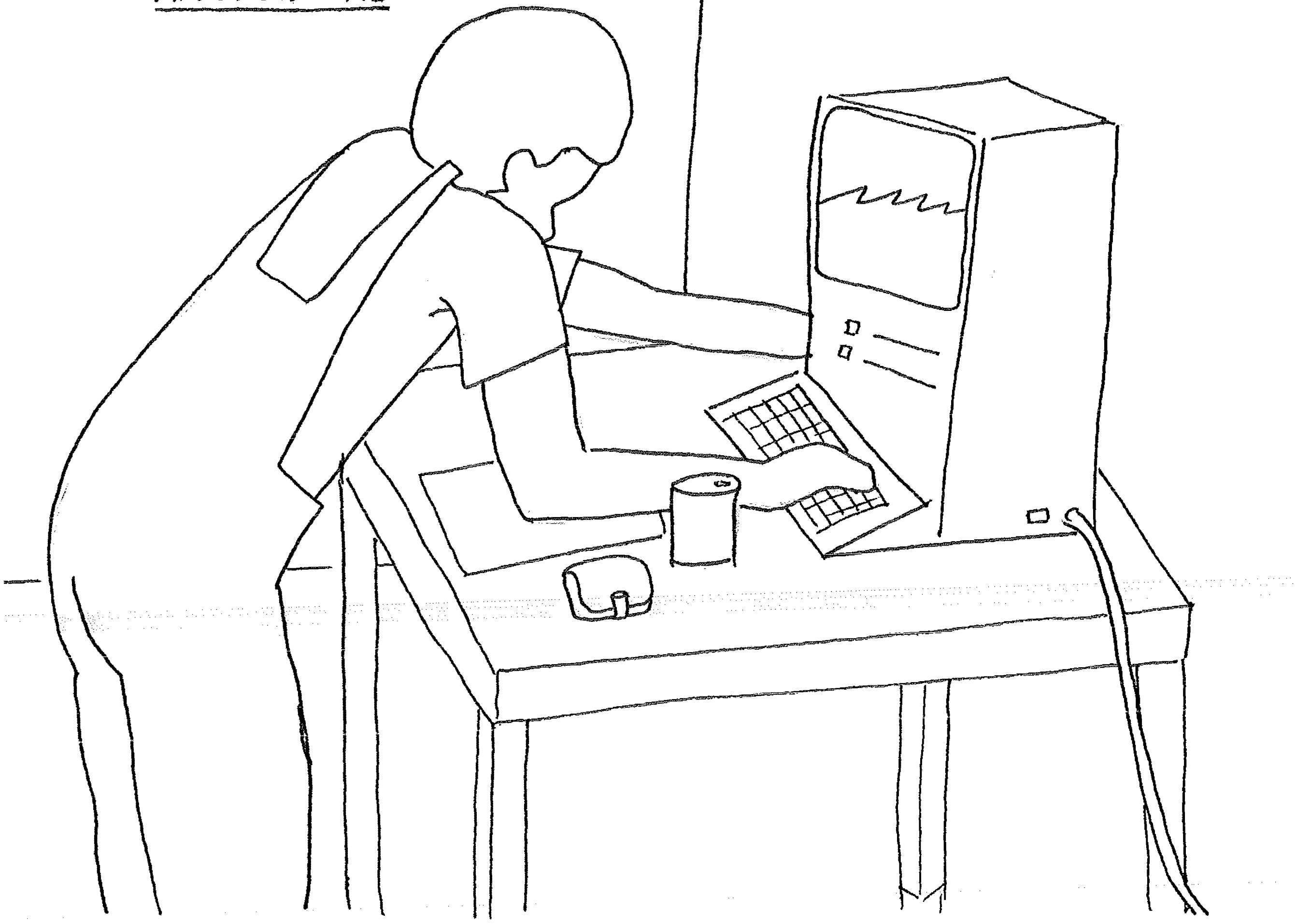
Watkins, M.J. (1990). Mediationism and the obfuscation of memory. *American Psychologist, 45,* 328-335.

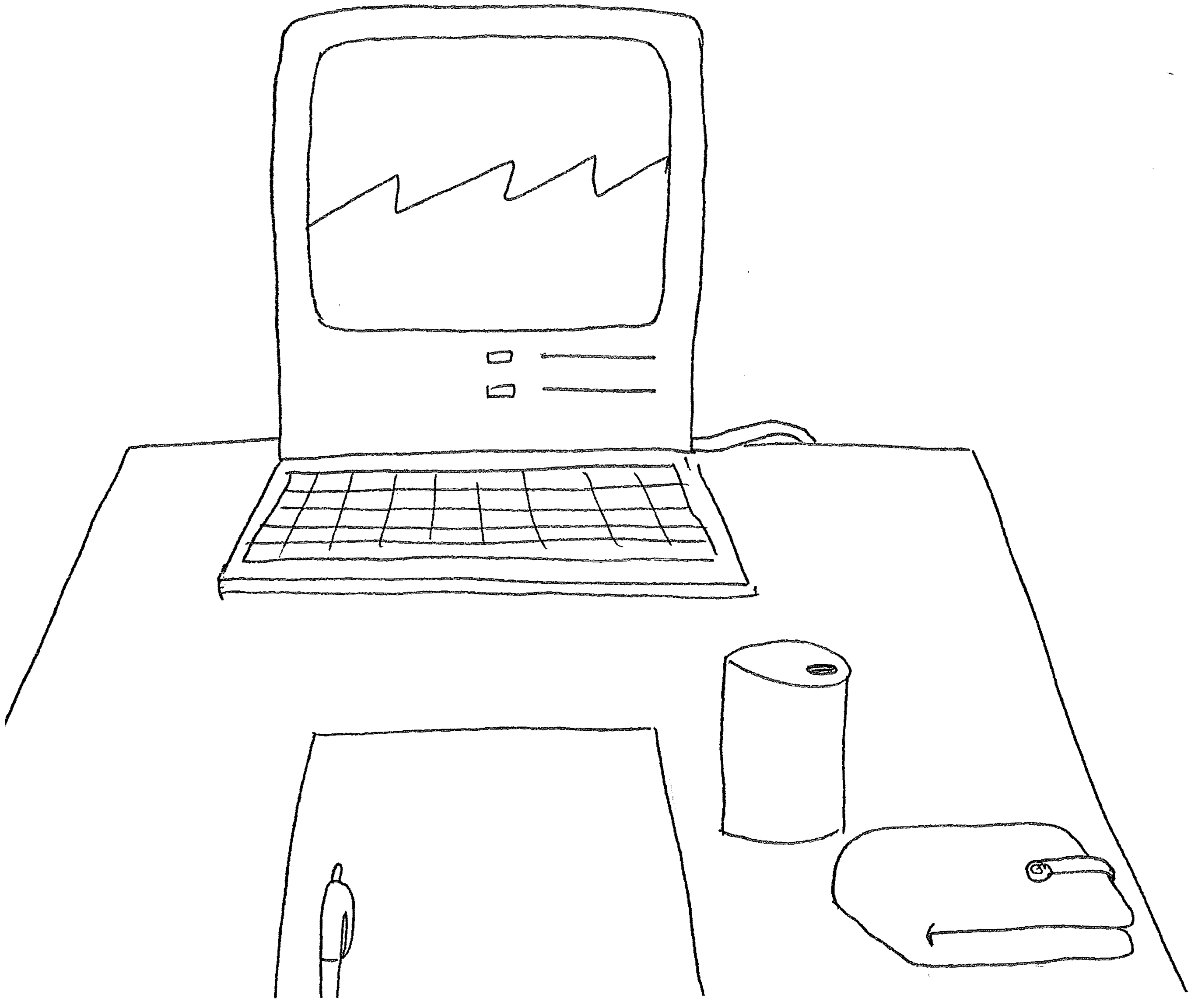
Zaragoza, M.S., McCloskey, M., & Jamis, M. (1987). Misleading post-event information and recall of the original event: further evidence against the memory impairment hypothesis. *Journal of Experimental Psychology: Learning, memory and cognition, 13,* 36-44.

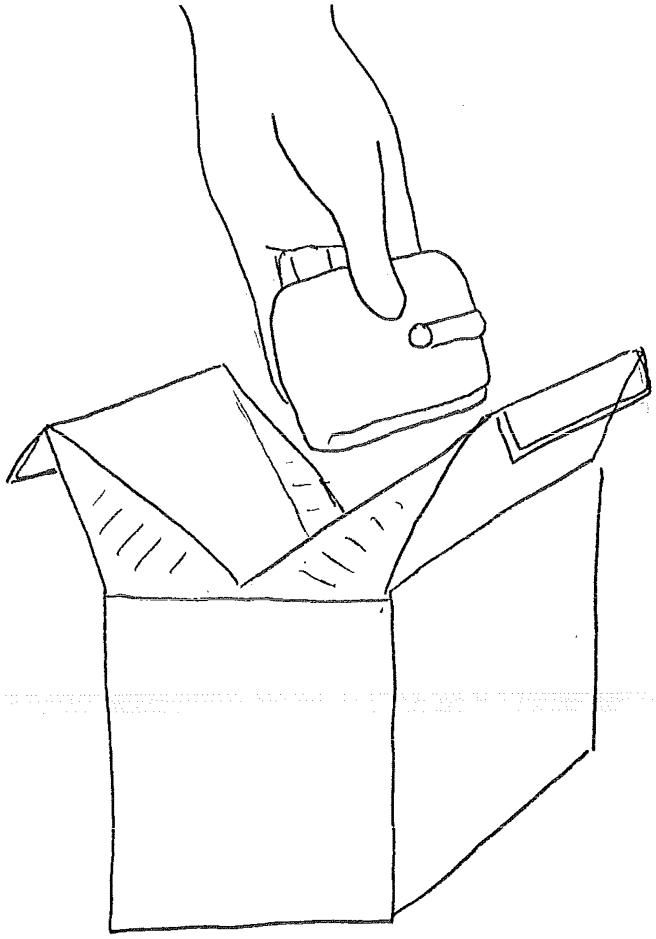
Zaragoza, M.S., & Koshmider III. (1989). Misled subjects know more than their performance implies. *Journal of Experimental Psychology: Learning, memory and cognition, 15,* 246-255.

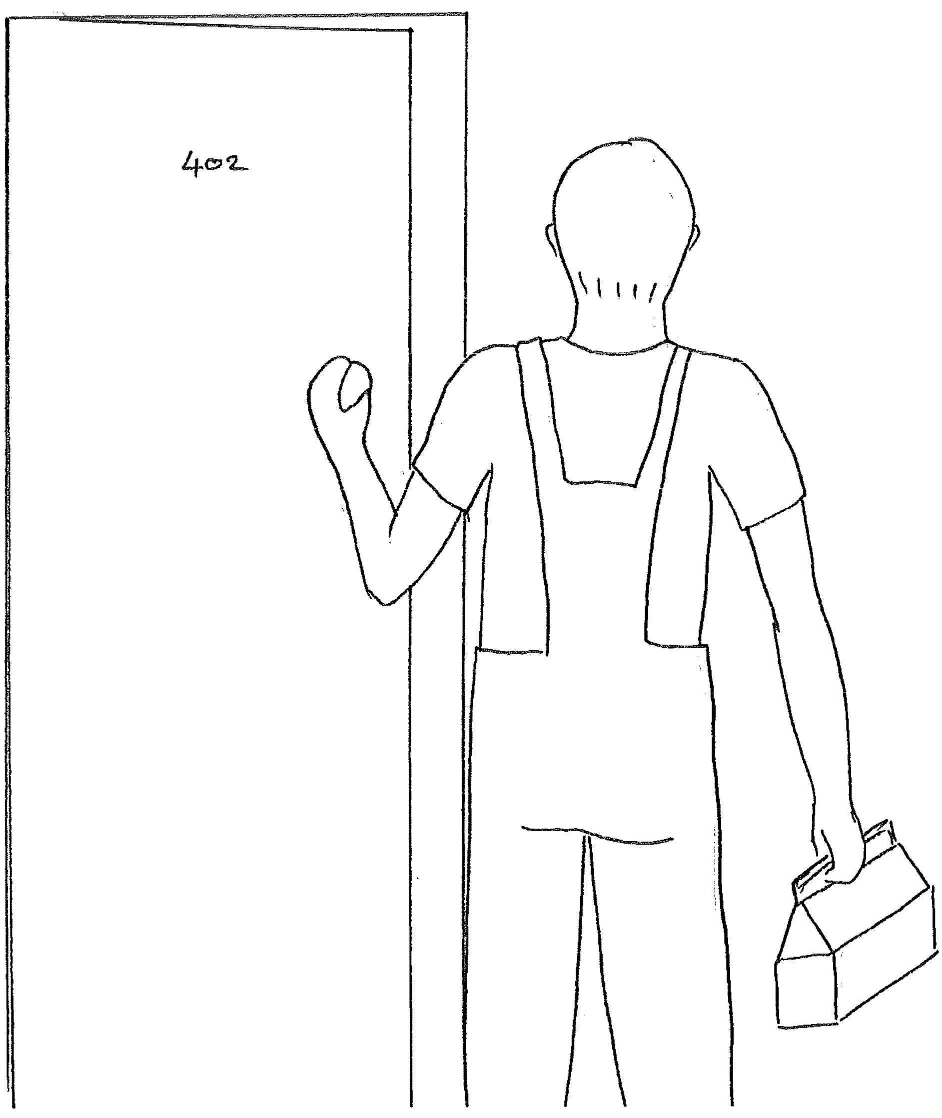
Examples of stimuli used in Experiment 1.

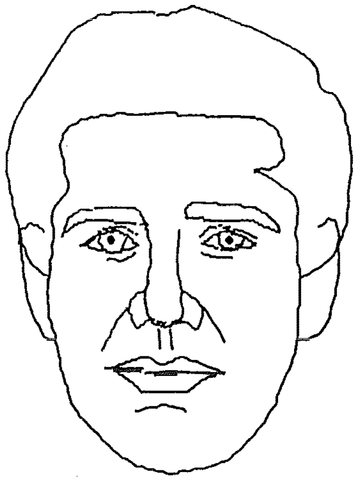
APPENDIX ONE





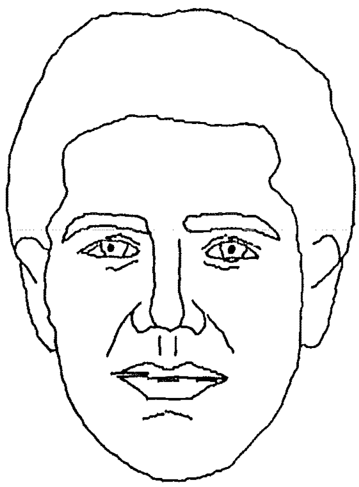



402



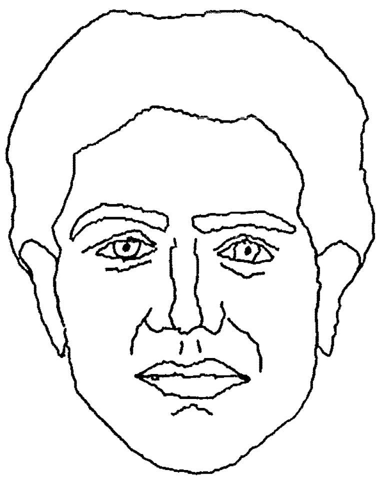
Bob.

3.



BLEND.

1.



Brian.

Appendix Two

Condition	Original	Blend	Interpolated	Novel
	Response Categories			
Control	.569	.304	.118	.009
Misled	.276	.409	.305	.009

Mean proportion of subjects who selected each response type in the misled and control condition of Experiment 1.

Tests for significant differences between proportions

1. Original face: Control = .569 Misled = .276

$$z = \frac{P - P}{\sqrt{\frac{P(1-P)}{N} + \frac{P(1-P)}{N}}}$$

$$= \frac{.569 - .276}{\sqrt{\frac{.569(1-.569)}{102} + \frac{.276(1-.276)}{105}}}$$

$$= \frac{0.293}{0.065}$$

$$z = 4.507$$

$z(207) = 4.507$, $p < .05$

2. Blend face: Control = .304 Misled = .410

$$z = \frac{.40 - .304}{\sqrt{\frac{.410(1-.410)}{105} + \frac{.304(1-.304)}{102}}}$$

$$= \frac{0.106}{0.066}$$

$$= 1.61$$

$z(207) = 1.61$, $p > .05$ ns

3. Misleading face: Control = .118 Misled = .305

$$z = \frac{.118 - .305}{\sqrt{\frac{.118(1-.118)}{102} + \frac{.305(1-.305)}{105}}}$$

$$= \frac{-0.187}{0.055}$$

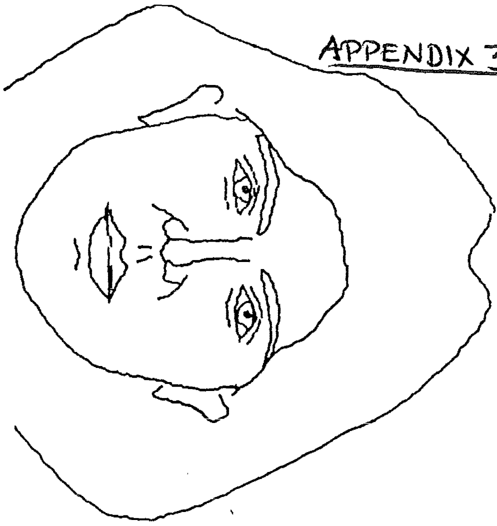
$$= 3.40$$

$z(207) = 3.40$, $p < .05$

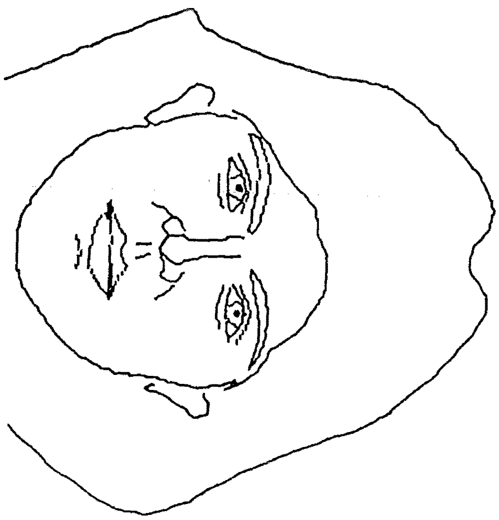
Fig. 5.

APPENDIX 3

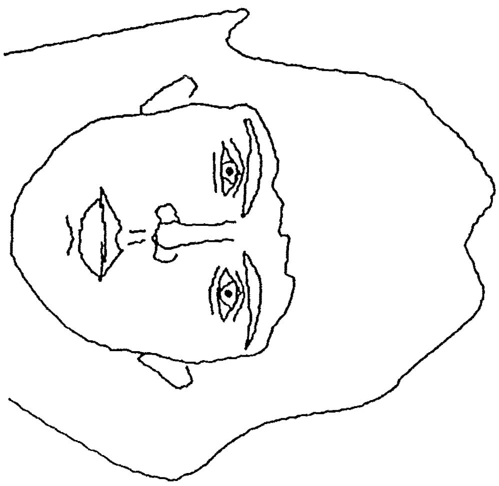
Examples of Stimuli used in Experiment 2.



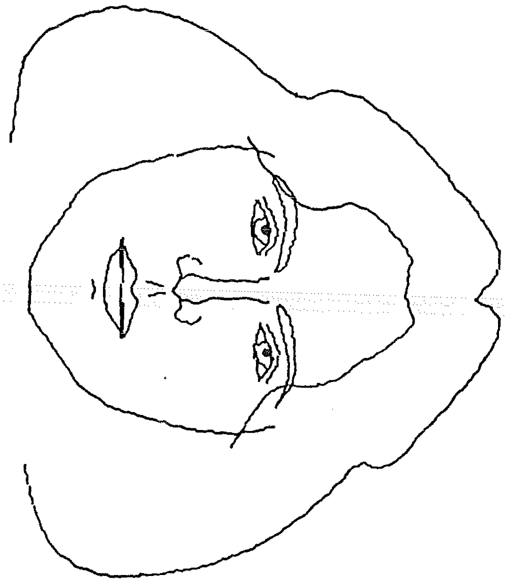
(50)



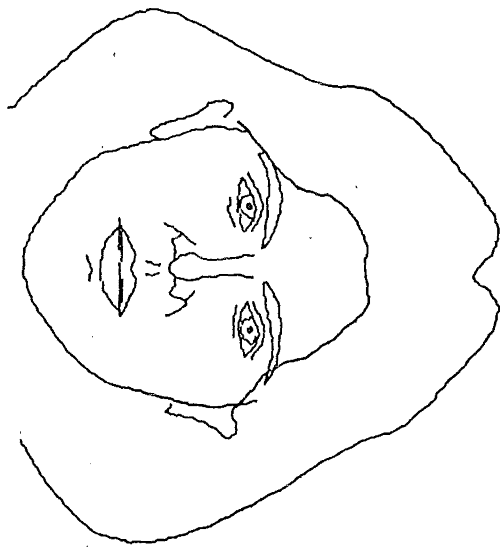
(67)



Jenny (100)



Jane (0)



(33)

Appendix Four

Raw data for Experiment 2: See sheets.

1 = Typical, 7 = Not Typical

S	Jane	Jane(2)/Jenny	Jane/Jenny	Jane/Jenny(2)
1	5	4	5	5
2	5	3	4	2
3	4	5	3	5
4	5	4	1	5
5	5	4	4	4
6	5	4	5	4
7	4	7	4	6
8	5	7	4	3
9	4	3	5	3
10	4	5	5	3
11	5	4	3	6
12	5	4	3	4
13	7	4	3	4
14	5	4	4	6
15	5	3	4	4
16	7	3	5	4
17	6	3	5	6
18	4	4	3	3
19	6	5	3	2
20	5	4	5	6
21	4	4	4	3
22	4	7	5	6
23	4	4	4	4
24	6	3	5	3
25	5	4	5	3
26	5	5	3	5
27	5	5	3	4
28	5	5	4	5
29	4	4	4	4
30	5	4	3	4

Experiment 2
1=Novel; 2=0; 3=33; 4=50; 5=67; 6=100.

	Misled Condition		Control Condition	
S	Choice	Confidence	Choice	Confidence
1	50	7	100	6
2	33	6	67	7
3	100	2	33	5
4	50	5	100	7
5	33	5	100	7
6	67	6	100	7
7	67	4	100	5
8	67	7	67	5
9	33	7	50	6
10	50	5	100	6
11	50	7	67	4
12	67	3	100	7
13	0	3	67	3
14	100	6	67	5
15	100	5	33	5
16	0	4	67	7
17	50	4	50	6
18	50	5	100	7
19	67	6	100	6
20	0	3	33	3
21	0	6	100	7
22	100	3	100	5
23	0	4	100	7
24	50	6	50	4
25	67	6	67	6
26	67	3	50	5
27	50	3	50	4
28	67	3	100	7
29	0	6	33	6
30	50	4	67	6

0 = Misleading face
33 = 33% of original face
50 = 50% of original face
67 = 67% of original face
100 = original face

Confidence Ratings

S	*Control*	*Misled*
1	6	7
2	7	6
3	5	2
4	5	5
5	7	5
6	7	6
7	7	4
8	5	7
9	6	7
10	6	5
11	4	7
12	7	3
13	3	3
14	5	6
15	5	5
16	7	4
17	6	4
18	7	5
19	6	6
20	3	3
21	7	6
22	5	3
23	7	4
24	4	6
25	6	6
26	5	3
27	4	3
28	7	3
29	6	6
30	6	4

1 = Low Distinctiveness
7 = Very Distinctive

Experiment 2
TYPICALITY - Male

Where 1 = Typical, 7 = Not Typical

S	Bob	Bob(2)/Brian	Bob/Brian	Bob/Brian(2)
1	4	4	2	2
2	2	4	4	5
3	4	2	4	5
4	3	1	6	6
5	3	4	2	4
6	2	6	4	4
7	3	3	6	4
8	4	3	4	6
9	5	3	4	5
10	4	4	6	2
11	4	2	5	5
12	4	3	2	4
13	2	4	3	3
14	2	2	3	3
15	3	2	4	4
16	6	3	2	2
17	4	4	2	2
18	3	4	5	6
19	4	4	4	4
20	3	3	4	4
21	3	3	3	3
22	4	2	3	3
23	4	4	5	6
24	4	3	4	4
25	3	3	4	4
26	3	3	3	5
27	2	5	5	4
28	4	5	3	4
29	3	5	4	5
30	3	6	4	4

Appendix Five

Statistical Analyses for Experiment 2.

	Face Response as % of original face presented				
Condition	*Novel*	*0*	*33*	*50*	*67*
Misled	-	20.00	10.00	30.00	26.0
Control	-	-	13.33	16.67	26.6

Percentage of subjects who selected each face in the misled and control condition of Experiment 2.

T-Tests (Face Response Choice)

$$t = \frac{\sum d}{\sqrt{\frac{N\sum d^2 - (\sum d)^2}{N - 1}}}$$

$$= \frac{733}{\sqrt{\frac{1904070-537289}{29}}}$$

$$= \frac{733}{217.09}$$

$$= 3.376$$

$t(29) = 3.38,\ p < .001$

T-Tests (Response Choice between Options)

Control selection ($\bar{x}$ = 73.93) and original option (100)

$$t(29) = \frac{\bar{x} - \bar{x}_o}{\frac{S_{D\bar{x}}}{\sqrt{N}}}$$

$$= \frac{73.93 - 100}{\frac{25.45}{\sqrt{30}}}$$

$$= \frac{-26.07}{4.64}$$

$$= -5.62$$

$t(29) = -5.62$, $p < .001$

Control selection ($\bar{x}$ = 73.93) and 67% original option

$$= \frac{73.93 - 67}{\frac{25.45}{\sqrt{30}}}$$

$$= \frac{6.93}{4.64}$$

$$= 1.49$$

$t(29) = 1.49, p > .05$

Control selection ($\bar{x}$ = 73.93) and 50% original option

$$= \frac{73.93 - 50}{4.64}$$

$= 5.16$

$t(29) = 5.16, p < .01$

Misled selection ($\bar{x} = 49.50$) and 50% original option

$$t = \frac{49.50 - 50.00}{\frac{31.16}{\sqrt{30}}}$$

$$= \frac{-0.5}{5.69}$$

$$= -0.088$$

$t(29) = -0.088$, $p > .05$

T-Test: Confidence ratings of control and misled subjects

$$t = \frac{\sum d}{\sqrt{\dfrac{N\sum d^2 - (\sum d)^2}{N - 1}}}$$

$$= \frac{27}{\sqrt{\dfrac{30.117-(27)^2}{30 - 1}}}$$

$$= \frac{27}{9.79}$$

$$= 2.78$$

$t\,(29) = 2.78,\ p < .01$

T-Test Typicality Ratings: Jane/50% Blend (Jenny/Jane)

$$t = \frac{\Sigma d}{\frac{N\Sigma d^2 - (\Sigma d)^2}{N - 1}}$$

$$= \frac{30}{\frac{\sqrt{30.78 - (30)^2}}{30 - 1}}$$

$$= \frac{30}{7.05}$$

$$= 4.26$$

$t(29) = 4.26,\ p < .01$

Jenny/50% Blend (Jenny/Jane)

$$t = \frac{20}{\sqrt{\frac{20.56 - (20)^2}{30 - 1}}}$$

$$= \frac{20}{4.98}$$

$$= 4.01$$

$t(29) = 4.01, p < .01$

Blend (Bob/Brian)/Bob

$$= \frac{16}{\sqrt{\frac{30.84-(16)^2}{30}}}$$

$$= \frac{16}{8.84}$$

$$= 1.81$$

$t(29) = 1.81$, $p > .05$

Blend (Brian/Bob)/Brian

$$t = \frac{22}{\sqrt{\frac{30.108-(30)^2}{30-1}}}$$

$$= \frac{22}{8.98}$$

$$= 2.45$$

$t(29) = 2.45, p < .05$